CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 40 JULY, 1954 NUMBER 3

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CHANGE OF EDITORSHIP

With this issue, a new editor takes over the important task of assembling the material on fish and game conservation and investigation which appears in *California Fish and Game*.

In recent years the department has had a policy of rotating the editorship between staff members of the three fact-finding units, the branches of Inland Fisheries, Marine Fisheries and Game Management.

For four years, Phil M. Roedel of Marine Fisheries has been in charge of this publication, in addition to discharging rather heavy duties as assistant supervisor of the State Fisheries Laboratory at Terminal Island. In Mr. Roedel's hands *California Fish and Game* has maintained its high standards in presenting to the interested public the results of scientific investigations upon which management programs are based.

To Mr. Roedel we express our appreciation for a job well done. We are happy that he will continue to serve as associate editor for marine fisheries.

The new editor-in-chief is Leo Shapovalov, senior biologist of the Inland Fisheries Branch. Mr. Shapovalov, who has been with the department since 1932, brings to his new assignment a world of experience in fisheries research and management. He is the author of numerous articles on steelhead, salmon and freshwater fishes, and is well fitted to take over this important assignment.

To assure balance and a broad base of experience in presenting important facts in a readable manner, Mr. Shapovalov will be assisted by three associate editors. Carol Ferrel, game management, and J. B. Kimsey, inland fisheries, along with Mr. Roedel, will form the editorial staff.—*Seth Gordon, Director, California Department of Fish and Game.*

DEER AND FORAGE RELATIONSHIP ON THE LASSEN-WASHOE INTERSTATE WINTER DEER RANGE[1]

WILLIAM P. DASMANN and JAMES A. BLAISDELL
Game Management Branch
California Department of Fish and Game

INTRODUCTION

During the past seven years the California Department of Fish and Game has carried on a series of range investigations in conjunction with deer herd management studies. One of these investigations is in progress on the Lassen-Washoe interstate winter deer range. The study area is located principally along the boundary line between Lassen County, California, and Washoe County, Nevada, in the vicinity of the Town of Doyle. It includes the Doyle deer management unit and part of the Loyalton-Truckee management unit (Figure 1) and embraces 228,400 acres of public and private lands which make up the winter range of a herd of Rocky Mountain mule deer (*Odocoileus hemionus hemionus*).

The investigation was initiated in the fall of 1948 by the California Department of Fish and Game. The following year a cooperative study group was organized to take over and expand the investigation. This committee is made up of representatives of agencies responsible for administration of the land, livestock, and/or game animals of the area. Representative sportsmen and ranchers are invited to act in an advisory capacity. The agencies participating in the study are the Nevada Fish and Game Commission, the U. S. Forest Service, Regions IV and V; the Bureau of Land Management, Districts C2 and N3; and the California Department of Fish and Game. The objective of the cooperative investigation is to gather factual data from which to formulate a management plan acceptable to all interests.

The range studies have consisted primarily of (1) surveys to inventory the kind and the condition of vegetation now present on the winter range; (2) utilization checks to determine the amount of browsing by livestock and deer from year to year; (3) deer pellet group counts to point out concentration areas and provide information on trends in deer numbers. Deer herd studies, which have been carried on concurrently with the range investigation, have yielded annual data on fawn production and survival.

The findings of several phases of the study have been reported previously (Lassen et al., 1952; Blaisdell, 1953). This paper is concerned with the relationship of deer production and survival with various range factors. It provides evidence to support the belief that bitterbrush (*Purshia tridentata*) is important as an indicator species in management of the deer herds wintering on the Lassen-Washoe range.

[1] Submitted for publication January, 1954.
Assistance was given the investigation by personnel of Pittman-Robertson Projects California W-41R and Nevada W3R. These projects are supported by funds provided through the Federal Aid to Wildlife Restoration Act.

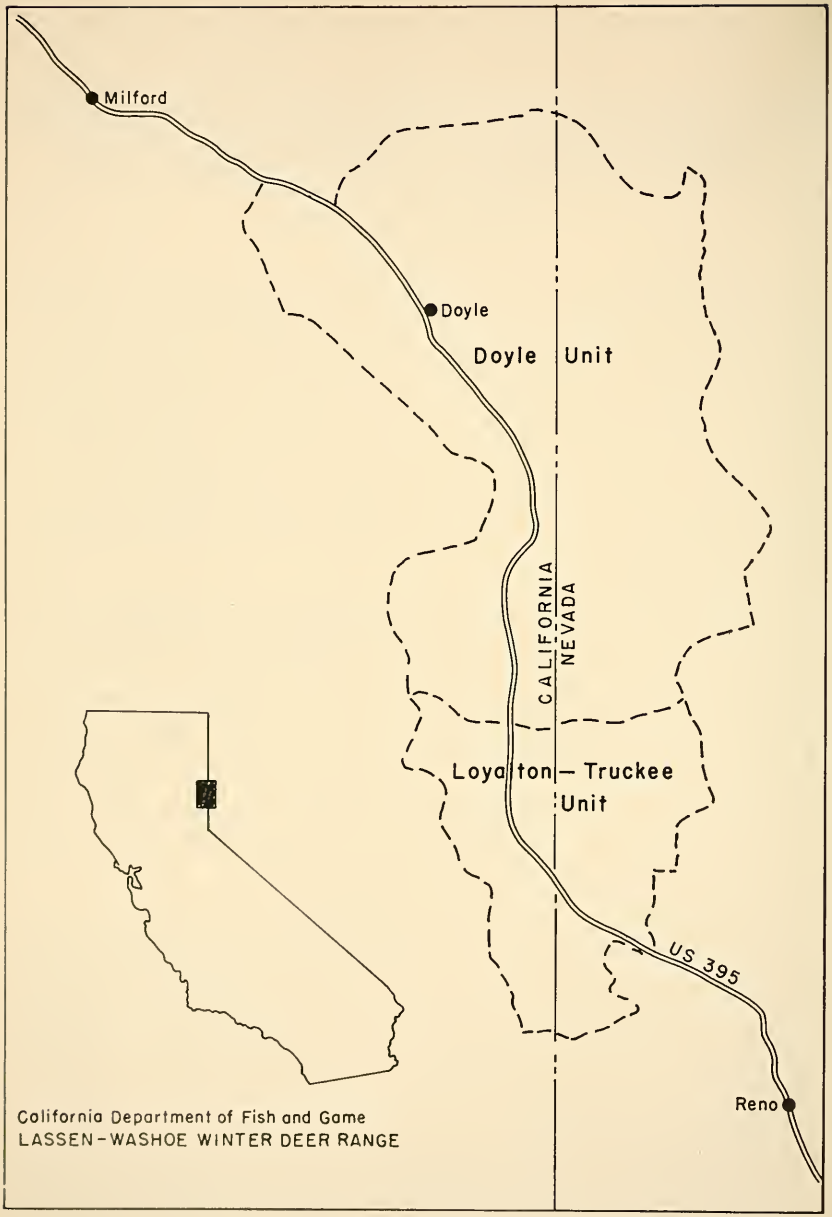

FIGURE 1. Map of the Lassen-Washoe winter deer range.

METHODS USED IN THE INVESTIGATION

Inventory Methods

A line-point method of ground-cover inventory has been employed in range studies on the Lassen-Washoe area. The method is similar to that described by Parker (1942), and does not greatly differ from that now integrated into the Parker Three-step method (Parker, 1951; 1953). A hundred-foot metal band tape was stretched between two permanently established iron rods. At each of the footmarks on the tape, a plumb was taken. The classes of ground cover which occurred directly under or over the footmarks were recorded. Bare ground, rock, litter, annual grass, and annual or perennial forbs, were considered hit when one of these classes dominated the area of a four-inch circle directly under the line-point. Hits on perennial grasses were limited to instances where the line-point fell above the root crown, rather than the leafage of the plants. With browses, a hit was recorded when the line-point fell within the average perimeter of the shrub or tree, even though the point was directly over or under an inter-space. Where dead browse plants or dead portions of living browses occurred at the line-points, the hits were classified as "dead species." Other differences from the three-step method were as follows: (1) rock was defined as any rock an inch or more in diameter; (2) erosion pavement was not classified separately from bare ground; (3) where available browse occurred at a line-point, no record was made of the ground cover beneath it; (4) only single plots, rather than clusters, were used at each sample site in order to get a wider ground coverage.

Along with the survey of ground cover, the individual browse plants hit by line-points were classed as to form and age. The age classes used were seedlings, young plants, mature plants, and decadent plants. Shrubs of which 25 percent or more of the crown was dead were classified as decadent. Form classes, as defined in these surveys, were a composite of degree of hedging and of availability of forage. Degree of hedging was broken down into (1) not hedged or lightly hedged, (2) moderately hedged, or (3) heavily hedged. Browses were classified for availability as (1) all available, (2) partly available, (3) mostly unavailable, or (4) unavailable. These classifications were more fully described by Dasmann (1951) and Parker (1953).

In the Lassen-Washoe investigation, it was an objective to classify at least three of each of the more heavily utilized browse species for age and form at each plot site. Where at least three were not hit by line-points, but representatives were present on the area adjacent to the plot, the quota was filled by inclusion of bushes closest to the tape.

The line-point method is designed to yield data representative of frequency and hence percentage of cover. Because observations are limited to a series of points along a line, the probability of hitting small plants is somewhat less than that for large plants, even though all sizes are equally present on an area. Hence the method used on the Lassen-Washoe range to obtain data on form and age classes yielded findings which are valid as indices of frequency of occurrence of the various classes of shrubs encountered on the plots, but are not necessarily representative of actual age and form class composition of the browse stand.

Utilization Surveys

The visual estimate method was used for checking utilization of browses and forbs, except that the twig measurement method was used on juniper (*Juniperus occidentalis*). Visual estimates of percentage cropping of browses were calculated as a result of a consideration of (1) unbrowsed leader lengths, (2) browsed leader lengths, and (3) the proportion of the leaders which was browsed. A record was kept of all unbrowsed leader length estimates. These were averaged each fall and used as an index of the year's growth. These methods are described by Hormay (1943), Aldous (1945), Dasmann (1947; 1951), and others. The height-weight method was used for estimating the percentage utilization of perennial grasses (Lomasson and Jensen, 1942). Utilization checks were made in October and April of each growth year.

Pellet Counts

Pellet group counts were made at the sites on which forage plots were established. Pellet sample plots were 11 chains long by 6 feet wide, giving an area coverage of one-tenth acre. Plots were defined by pacing five chains out, one chain across, and five chains back. Only droppings of the season were counted. These were distinguished from those of previous years by color and shine. Unless more than half the droppings in a group occurred on the plot, the group was not tallied. A more detailed description of the method will be found in the Devils Garden Interstate Deer Herd Committee progress report (Interstate Deer Herd Committee, 1951).

Deer Herd Composition

Deer herd composition was based on careful counts made (1) during the rutting season, in late November and December, and (2) at the end of the winter period, in April. During the first count, the animals were classified as bucks, does, or fawns. At the time of the spring count, the deer were classed as adults or fawns, since at this season bucks are difficult to distinguish from does, because they lack antlers. For comparative purposes, it was assumed that the proportion of bucks to does in the spring was the same as that found the previous fall. The adult: fawn ratios were converted to doe: fawn ratios, by use of fall percentages. No groups of deer were included in the tally unless every individual in the group was classified. Counts were made with binoculars to reduce the possibility of misclassification.

TRAINING

In training men to estimate forage utilization, initial practice consisted of manual measurements of leader lengths, actual counts of cropped and uncropped leaders, and paper calculations of percentage cropping. After the crew members became familiar with the basic procedure, and proficient at estimating twig lengths, straight visual estimation was substituted. Training continued until the individual range examiner's average for practice runs of 10 shrubs fell within a range of the crew average plus or minus 10 percentage points, i.e., 45 ± 10 percentage utilization.

The range investigations did not aim at procurement of exact data, as might be gained from precise manual measurements or other time

consuming techniques. Rather, only methods which appeared practical for general use by field personnel were developed and employed. Findings were compiled as arithmetical averages, and such are used throughout this paper. Some statistical averages, together with confidence limits, are given in Table 13 to allow comparison.

FINDINGS

Most of the data presented in this section have been reported by Blaisdell (1953) and part of them have been reported by Lassen et al. (1952). The findings are included here for the sake of completeness, since they constitute the material analyzed in the succeeding section.

Ground Cover Inventory

A total of 235 line-point plots was established on the Lassen-Washoe range during the study period, 161 in 1949, 48 in 1950, and 26 in 1951. These plots were located along roads, trails, and ways at predetermined, mechanical intervals. The plots did not constitute a strictly random sample, but they are considered to make up a close approximation.

The line-point inventory of the ground cover revealed that 32.1 percent of the ground was covered by vegetation available to deer and livestock, of which 11 percent was annual vegetation and 21.1 perennial grasses, forbs, and browses. Sagebrush (*Artemesia tridentata*) was by far the most abundant shrub on the range, covering 12.2 percent of the ground surface. It was followed in descending order by bitterbrush, rabbitbrush(*Chrysothamnus* spp.) desert peach (*Prunus andersonii*), horsebrush (*Tetradymia canescens*), and western juniper. These six browse species made up 19.5 percent of the ground cover. Perennial grass covered only 0.5 percent of the ground surface and perennial forbs only 0.2 percent. All other perennial vegetation made up but 0.9 percent of the ground cover. Table 1 gives a tabular breakdown of the findings.

Dead browses covered 6.7 percent of the ground surface, dead sagebrush covering 3.5 percent and dead bitterbrush 0.8 percent. Of the total coverage by sagebrush and bitterbrush, both living and dead, 22.3 percent of the sagebrush cover was dead and 22.9 percent of the bitterbrush cover was dead. The amount of dead bitterbrush particularly is a matter of concern in view of the low percentage of young bitterbrush plants occurring on the plots, as pointed out below. At the present time, there is little replacement by reproduction of the dead and dying bitterbrush plants on the Lassen-Washoe range.

The first surveys, made in 1949-50, revealed that bitterbrush was the most heavily cropped browse on the range, as shown by both degree of hedging and by current utilization. This browse has been considered the key forage species, since no other important browse is apt to be over-browsed, so long as the utilization of bitterbrush is kept within proper limits. For this reason, the age and form class data given below are limited to this important shrub.

To provide a basis for comparison, the data are compared with those reported for the Devils Garden interstate winter deer range (Interstate Deer Herd Committee, 1951).

TABLE 1

Ground Cover Inventory
(Based on 235 line-point Plots)

Class of cover	Percent of ground surface		Number of plots w/cover	Percentage composition
Bare ground		32.3	234	
Litter		28.9	235	
Dead shrubs		6.7		
Bitterbrush (*Purshia tridentata*)	0.8		64	
Desert peach (*Prunus andersonii*)	0.7		27	
Rabbitbrush (*Chrysothamnus* spp.)	1.1		58	
Sagebrush (*Artemisia* spp.)	3.5		160	
Others	0.6		42	
Total nonproductive		67.9	--	
Annual grasses		10.0	191	31.2
Annual forbs		1.0	77	3.1
Total annuals		11.0	--	34.3
Perennial grasses		0.5	--	1.5
Idaho fescue (*Festuca idahoensis*)	0.1		5	
Indian rice grass (*Oryzopsis hymenoides*)	0.1		6	
Sandberg blue grass (*Poa secunda*)	0.1		5	
Squirreltail grass (*Sitanion hystrix*)	0.1		16	
Needlegrass (*Stipa* spp.)	0.1		10	
Perennial forbs		0.2	--	0.6
Arrowleaf balsam root (*Balsamorhyza* sp.)	0.1		10	
Buckwheats (*Eriogonum* spp.)	0.1		7	
Total perennial herbs		0.7	--	2.1
Sagebrush (*Artemisia* spp.)		12.2	211	38.0
Bitterbrush (*Purshia tridentata*)		2.7	98	8.5
Rabbitbrush (*Chrysothamnus* spp.)		1.5	78	4.6
Desert peach (*Prunus andersonii*)		1.4	57	4.4
Horsebrush (*Tetradymia* sp.)		1.1	51	3.4
Juniper (*Juniperus occidentalis*)		0.6	15	1.9
Wild currant (*Ribes* spp.)		0.3	21	0.9
Desert tea (*Ephedra viridis*)		0.1	10	0.3
Hop sage (*Grayia spinosa*)		0.1	5	0.3
Aspen (*Populus tremuloides*)		0.1	3	0.3
Total browses		20.1	--	62.6
Unclassified		0.3	20	1.0
Grand total		100.0	235	100.0

The age class data presented in Table 2 indicate that the condition of the Lassen-Washoe bitterbrush stand is far worse than that of the Devils Garden. The index reveals that on the Lassen-Washoe area there are less than one-third the number of young plants and more than half again as many decadent plants as were found on the Devils Garden range, a range that itself presents a deer forage problem. This, coupled with the high percentage of dead bitterbrush found on the Lassen-Washoe range, poses a critical factor in management of the deer herd. The form class index, given in Table 3, reveals that 78.8 percent of the bitterbrush plants checked on the Lassen-Washoe range were heavily hedged, as compared to 30.7 percent on the Devils Garden.

TABLE 2

Bitterbrush Age Class Index

Class	Percentage of total plants classified	
	Lassen-Washoe	Devil's Garden
Seedlings	0.0	1.0
Young plants	4.3	15.4
Mature plants	52.2	55.6
Decadent plants	43.5	28.0

The severity of browsing which results in heavily hedged bitterbrush is considered damaging to sustained maximum production of browse forage.

Pellet Counts

The amount of deer dung on an area may be used as an indicator of total deer pressure on range forage. A count of deer pellet groups on plots scattered throughout the Lassen-Washoe range yielded averages which reflect the number of deer on the area each year multiplied by their length of stay. These averages may be used directly as an index of intensity of range use by deer. The averages for the four winters under consideration were as follows:

1949-50	261 groups per acre
1950-51	276 groups per acre
1951-52	438 groups per acre
1952-53	236 groups per acre

The highest pressure occurred during the winter of 1951-52, when record snowfalls drove in deer from marginal ranges and confined them on the study area for a protracted period. The lowest pressure occurred during the relatively mild, open winter of 1952-53, when the deer herd, which had been reduced by the die-off of the previous year, remained scattered on the range.

TABLE 3

Bitterbrush Form Class Index

Class	Percentage of total plants classified	
	Lassen-Washoe	Devil's Garden
All available, little or no hedging	4.8	11.7
All available, moderately hedged	12.3	53.9
All available, heavily hedged	74.9	30.3
Partly available, little or no hedging	0.6	0.6
Partly available, moderately hedged	2.1	2.8
Partly available, heavily hedged	3.9	0.4
Mostly unavailable	1.3	0.0
Unavailable	0.0	0.3

Forage Utilization

Forage utilization data are summarized in Table 4. During the first year's survey, all perennial plants hit by line-points, plus the off-line shrubs included in the age and form class survey, were checked for percentage cropping. Starting the second year, the number of plant species checked for utilization was reduced to the six, and the following year to the four, most important browses. In addition, twig measurements have been taken on juniper. To date, the amount of juniper browse taken on this range has been negligible. A few trees show heavy use; the balance, little or none. The volume of juniper browse found in sample deer stomachs collected from this range has been low (Lassen et al., 1952). Relatively few deer remain on the Lassen-Washoe winter deer range during the summer months. Hence, the utilization data secured in the fall can be assigned principally to livestock and rodents. While it is the practice of the ranchers to feed hay and concentrates to livestock during the winter, some livestock do feed on the range between October and April, and particularly so during mild winters. In the spring of 1951, the data on browse utilization from areas on which no livestock were reportedly present during the preceding winter were compiled separately. It was found that browsing was actually heavier on the livestock-free areas than on the rest of the range, as shown in Table 5. These findings were considered a strong indication that deer and rodents are primarily responsible for browse utilization on the Lassen-Washoe area during the winter period. The utilization data secured in April constitute the total taken by livestock, deer, and rodents. By subtracting the fall averages from the totals obtained in the spring, the balances are considered representative of the fraction taken principally by deer. The utilization data given in Table 6 have been compiled on this basis.

It will be seen at once that bitterbrush is by far the most heavily cropped browse on the winter range, both by livestock during the summer period and by deer during the winter. The amount of bitterbrush forage taken by rodents is negligible. Rodents appear to take a considerable fraction of hopsage (*Grayia spinosa*) and significant amounts of rabbitbrush and horsebrush.

Utilization of bitterbrush by livestock has averaged 24 percent of the current leader growth during the four-year investigation, while that by deer has averaged 35 percent. Plots on which percentage cropping of bitterbrush averages 60 percent or greater are considered as over-browsed. The degree to which each class of animal is responsible for over-browsing of bitterbrush is shown in Table 7. It will be seen that relatively few plots (11 percent) show heavy utilization as a result of summer livestock browsing as compared to the percentage of plots (54 percent) which show this condition after winter browsing by deer.

Growth Indices

As stated earlier, records were made of the estimated lengths of unbrowsed bitterbrush leaders on each shrub checked during fall forage surveys. These leader lengths were averaged to make an index of the amount of forage produced during the year in question. Such indices

TABLE 4

Forage Utilization Survey Findings, in Percentages

	Percentage ground cover	Fall, 1949			Spring, 1950			Fall, 1950			Spring, 1951			Fall, 1951			Spring, 1952			Fall, 1952			Spring, 1953		
		L	R	T	D/L	R	T	L	R	T	D/L	R	T	L	R	T	D/L	R	T	L	R	T	D/L	R	T
Sagebrush	12.2	2.2*	0.1*	2.3	11.9	0.8	12.7	1.4	0.7	2.1	9.6	3.6	13.2	0.3	0.1	0.4	10.7	2.2	12.9	0.6	0.0	0.6	3.7	0.1	3.8
Bitterbrush	2.9	24.5*	-----	24.5	66.6	0.2	66.8	27.6	0.3	27.9	61.4	0.4	61.8	17.6	0.3	17.9	56.9	0.6	57.5	23.8	†	23.8	49.3	†	49.3
Desert peach	1.4	1.2	-----	1.2	2.6	-----	2.6																		
Rabbitbrush	1.5	8.2*	1.4*	9.6	11.5	1.9	13.4	2.5*	5.8*	8.3	3.9	9.0	12.9	2.2	0.6	2.8	3.4	8.0	11.4	2.2	0.1	2.3	2.9	1.7	4.6
Horsebrush	1.1	4.7*	2.1*	6.8	15.1	3.9	19.0	4.8	2.2	7.0	6.7	5.1	11.8	1.8	3.9	5.7	5.6	5.7	11.3	1.9	0.1	2.0	2.1	0.1	2.2
Currant	0.3	-----	-----	3.4	5.7	-----	5.7	0.9	-----	0.9	0.9	-----	0.9												
Hopsage	0.1	-----	-----	6.7	7.7	9.8	17.5	3.8	23.1	26.9	3.7	24.5	28.2												
Desert tea	0.1	-----	-----	3.0	25.4	-----	25.4																		
		Dry			Green																				
Needlegrass	0.1	-----	-----	40.7	-----	-----	13.9																		
Squirreltail	0.1	-----	-----	12.7	-----	-----	1.5																		
Rice grass	0.1	-----	-----	41.5	-----	-----	16.2																		
Blue grass (*Poa* spp.)	0.1	-----	-----	39.0	-----	-----	5.4																		
Idahoe fescue	0.1	-----	-----	13.0	-----	-----	7.5																		
Salt grass (*Distichlis spicata*)	†	-----	-----	55.0	-----	-----	0.0																		

L = Livestock R = Rodents D/L = Livestock and deer T = Total * = Computed † = Trace

TABLE 5

Utilization on Livestock-free Areas Compared With Entire Range

	Percent utilization			
	Bitterbrush		Sagebrush	
	No livestock	Entire range	No livestock	Entire range
Fall survey, 1950	24	28	1	2
Spring survey, 1951	60	62	22	13
Number of plots	17	91	35	87

can be used to throw light on year-to-year fluctuations in percentage utilization. It is important in management to know whether fluctuations in percentage cropping arise from variations in forage production or from changing animal numbers.

The average bitterbrush leader lengths for the four growth years under consideration were as follows:

3.4 inches in 1949-50
3.1 inches in 1950-51
5.1 inches in 1951-52
3.5 inches in 1952-53

Forage production during the growing season of 1951 was about 54 percent greater than the average for the other three years studied.

TABLE 6

Utilization of Browses by Deer and Livestock

	Percentage utilization					
	Livestock	Deer	Total	Livestock	Deer	Total*
	Bitterbrush			Sagebrush		
1949-50	25	42	67	2	10	13
1950-51	28	34	62	1	8	13
1951-52	18	39	58	T	10	13
1952-53	24	25	49	1	3	4
Average	24	35	59	1	8	11
	Rabbitbrush			Horsebrush		
1949-50	8	3	13	5	10	19
1950-51	3	1	13	5	2	12
1951-52	2	1	11	2	4	11
1952-53	--	--	--	--	--	--
Average	--	--	--	--	--	--

* Includes rodent use.

TABLE 7

Distribution of Bitterbrush Utilization

Percentage utilization Classes	Percentage of total plots in each class									
	Fall					Spring				
	1949	1950	1951	1952	Average	1950	1951	1952	1953	Average
0-19.9	50	48	63	56	54	1	3	5	7	4
20-39.9	30	23	21	21	24	10	10	11	25	14
40-59.9	16	11	9	9	11	22	23	32	35	28
60 plus	4	18	7	14	11	67	64	52	33	54

Fawn Production and Survival

The most striking revelation of the deer herd studies on the Lassen-Washoe winter range was the heavy loss of fawns that occurred during some winters, after the fall herd composition counts had been made. The data presented in Table 8 serve to stress the importance of spring composition counts where information on survival is needed. In interpreting these count ratios, it should be remembered that actual fawn losses were somewhat greater than the ratios indicate, because the number of does on the range did not remain constant. Each winter there is a loss of older animals as well as fawns on the Lassen-Washoe range. On the other hand, the effect of winter mortality on the following year's doe : fawn ratio must also be considered. A heavy loss of fawns (potential yearlings) one winter will tend to make the succeeding fall fawn ratio higher than normal, and vice versa. The low survival after the winters of 1949-50 (12 per 100 does) and 1951-52 (29 per 100 does) are especially significant.

ANALYSIS OF FINDINGS

Forage Utilization: Fawn Survival

Because of the poorer quality of browse stems, as compared with tips, and because expenditure of energy per unit of food is increased where browsing is limited mostly to woody stems, it can be assumed that deer nutrition declines when these animals are forced to feed from

TABLE 8

Deer Herd Production Data—Number per 100 Does

Year	Fall			Spring	
	Bucks	Fawns	Number in sample	Fawns	Number in sample
1949-50	13	62	764	12	193
1950-51	17	49	831	48	600 (Appr.)
1951-52	11	64	1152	29	575
1952-53	15	65	1239	64	600 (Appr.)

heavily browsed shrubs. But with animals in the wild there is always question about the food values of various plant species, actual carrying capacity levels, and relation of animal mortality to levels of browsing intensity.

In order to learn if a consistent relation exists between deer browsing intensity and fawn survival on the Lassen-Washoe winter range, the forage utilization data and fawn survival data were analyzed as shown in Table 9. Here the spring doe: fawn ratios are compared with (1) total utilization of each of the four principal browse species, and (2) with utilization by deer. It will be seen that there is a general correlation between survival and utilization for all four browses, and for both total use and use by deer alone, and that a close correlation appears between survival and bitterbrush utilization by deer. This relationship is plotted in Figure 2. Whether the survival ratio of 48 fawns per 100 does in the spring of 1951 and that of 64 per 100 does in the spring of 1953 might have been greater had a higher ratio of fawns been present the previous fall, will have to be determined from future findings.

TABLE 9

Fawn Survival: Browse Utilization Relationship

Year	Fawns per 100 does	Bitterbrush	Sagebrush	Rabbitbrush	Horsebrush
Total use (livestock, deer, rodents)					
1949-50	12	67	13	13	19
1951-52	29	58	13	11	11
1950-51	48	62	13	13	12
1952-53	64	49	4	5	2
Winter use (principally by deer)					
1949-50	12	42	10	3	10
1951-52	29	39	10	1	4
1950-51	48	34	8	1	2
1952-53	64	25	3	3	0

Food habit studies of deer on the Lassen-Washoe range (Lassen et al., 1952) have revealed a decreasing volume of bitterbrush forage in the deer diet from October through January, with low volumes in February and March. This is accompanied by a build-up in the volume of sagebrush and herbaceous forage. A similar deer diet pattern was found on the Devils Garden winter deer range (Interstate Deer Herd Committee, 1951), where the volume dropped sharply in March and was marked by an increase in juniper browse and herbaceous foods. Although there appears to be a loss of fawns throughout the winter, rather heavy losses occur toward the end of an adverse season (Lassen et al., 1952), after the animals have shifted from a diet which contains significant volumes of bitterbrush to one in which sagebrush and herbaceous forages predominate.

It may be that an adequate diet of bitterbrush during the fore part of the winter helps to project some favorable body condition long

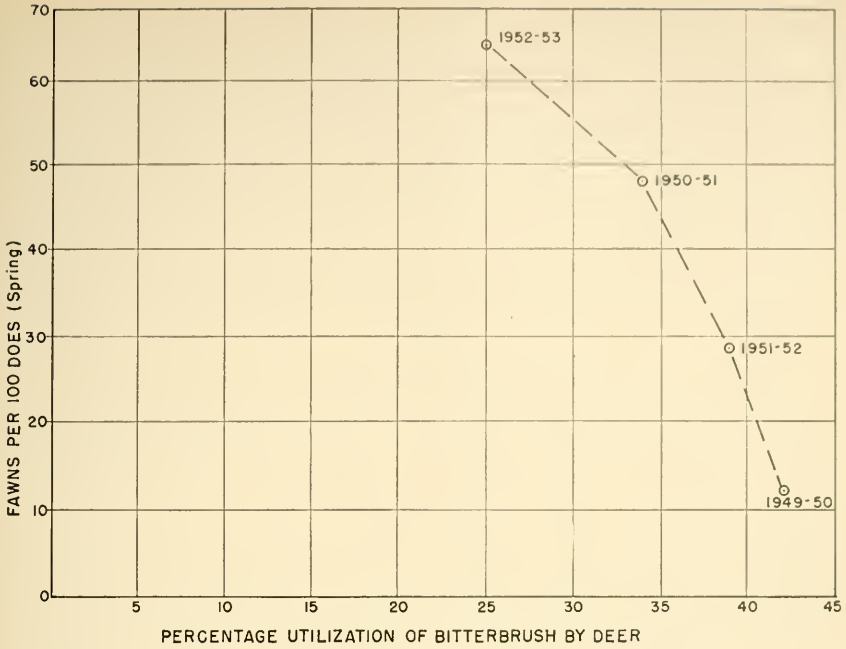

FIGURE 2. Relation of bitterbrush utilization to fawn survival.

enough into the adverse period following to provide the margin of safety needed to carry the animals through the balance of the season. On the other hand, the bitterbrush relationship may be not directly nutritional, but of a purely secondary nature. In other words, when deer are forced to browse bitterbrush heavily, it may be indicative of a condition, or combination of conditions, which will result in poorer fawn survival. The lowest survival occurred during the winter of 1949-50, a severely cold season with little green grass available. This can be contrasted with the much higher survival of 1950-51, a mild, open winter, when green grass was available much of the time (Lassen et al., 1952). In any event, a true relationship should prove useful as an indicator in management of the Lassen-Washoe deer herd.

Forage Utilization by Livestock and Deer

It should be remembered that livestock are in position to take the cream of the bitterbrush forage crop. Since they are on the range during the summer growing season, they can feed on this browse at a time when it is succulent and in full leaf. Deer, on the other hand, are forced to subsist on that which livestock leave. Although livestock cropping is not evenly distributed throughout the range, and extensive stands of bitterbrush do remain uncropped, or lightly cropped, until the deer arrive in the fall, livestock benefit from feeding on twig tips, while deer (on areas browsed by livestock) must fare on less nutritious stems (Aldous, 1945) that are approaching dormancy and leaf-drop at the time these animals arrive on the range.

Percentage utilization of bitterbrush leader growth by livestock and deer has varied from year to year, ranging from 18 to 28 percent for livestock and 25 to 42 percent for deer. In order to determine how much of this variation was due to changing volumes of growth and how much to changing pressure by range animals, the use index given in Table 10 was compiled. The index is a product of average leader length multiplied by percentage cropping. The products indicate how much of the average leader was consumed by livestock and how much by deer.

The graphic breakdown, given in Figure 3, shows that consumption of bitterbrush by livestock has been relatively constant during the four-

TABLE 10

Bitterbrush Use Index

Year	Average leader length (inches) × percentage utilization		
	Livestock	Deer	Total
1949-50	0.9	1.4	2.3
1951-52	0.9	2.0	2.9
1950-51	0.9	1.0	1.9
1952-53	0.8	0.9	1.7

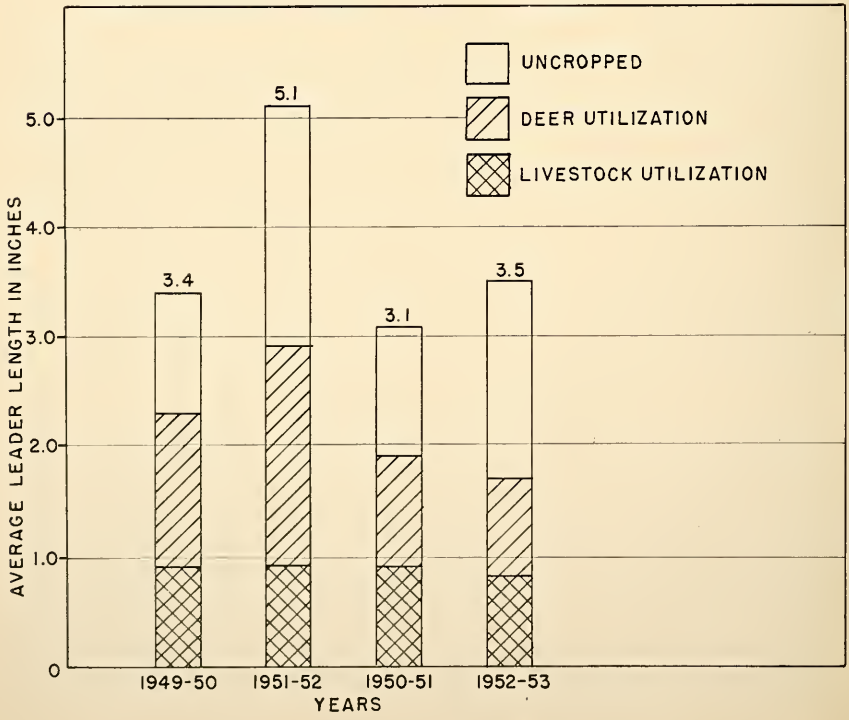

FIGURE 3. Utilization of average bitterbrush leaders.

year period. During good growth years percentage utilization by livestock goes down while during poor growth years it goes up; however, the volume of food taken remains relatively unchanged in either case. In contrast, range pressure by deer appears to be subject to considerable variation.

It should be pointed out that, although livestock demand appears constant, the impact of this browsing can be considerably greater in poor growth years, when these animals are forced to bite deeper into the shrunken supply of forage to fill out their demand, than in good years. Thus, a level of deer population which fares well on the forage left by livestock in a year of abundance might suffer from a food shortage in a year of dearth, even though livestock numbers remain unchanged.

The effect of livestock browsing of bitterbrush on the subsequent supply of forage for deer was greatest in 1950-51 and least in 1951-52. However, it will be seen from Table 9 that fawn survival was relatively high during the winter of 1950-51, while a heavy mortality occurred during the winter of 1951-52. Also, the heavy fawn loss of 1949-50 and the good survival of 1952-53 were not related to any significant difference in effect of livestock browsing, as indicated in Figure 3. It appears that the effect of livestock browsing on fawn survival has been constant, and that while survival has gone up and down with percentage cropping of bitterbrush by deer, the variation has operated independently of utilization of this browse by livestock during the period of study.

Bitterbrush Utilization: Deer Pressure Relationship

There remains unanswered the question whether variations in percentage utilization of bitterbrush leader growth by deer are a product of changes in population pressure or of a changing preference or need. In order to throw light on this relationship, the data were analyzed as shown in Table 11. Using a pellet group as a unit of deer pressure, and the number of pellet groups per acre as an indicator of total range pressure by deer, this pressure is compared in the table with bitterbrush use index data and with fawn survival data. The relationship is plotted in Figure 4. It will be seen there is good correlation with the exception of the data of 1949-50, the year of poorest fawn survival.

It appears evident that during the winter of 1949-50 deer consumed much more bitterbrush per unit of total range pressure than in any

TABLE 11

Relationship of Range Factors

Year	Fawns per 100 does	Pellet group per acre	Bitterbrush use index
1949-50	12	261	1.43
1951-52	29	438	1.99
1950-51	48	276	1.05
1952-53	64	236	0.88

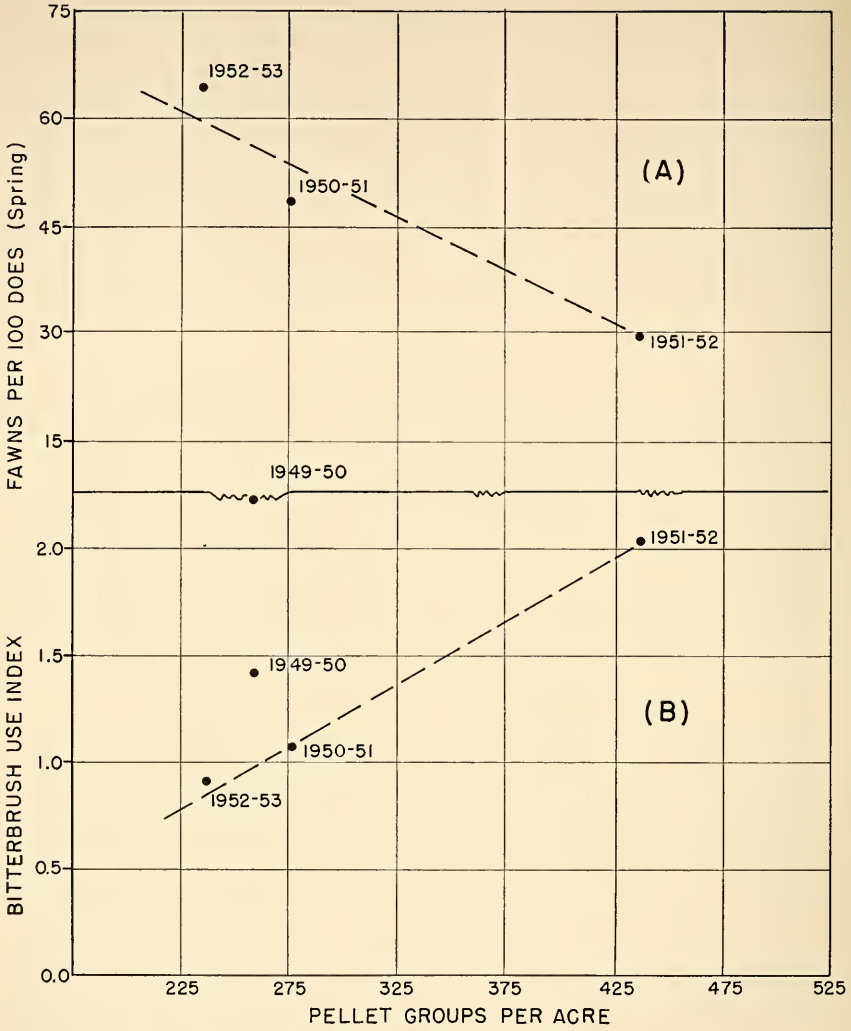

FIGURE 4. Relation of (A) fawn survival, and (B) inches of bitterbrush leaders consumed to total range pressure by deer.

other year, and that fawn survival was extremely low and out of all proportion to total range pressure by deer, as shown by the relationship existing during the other three years. During other years bitterbrush consumption rose and fell, and fawn survival went up and down, with total range pressure by deer. It would appear that increased animal numbers and/or length of stay was involved in the higher utilization of bitterbrush and lower survival of fawns in 1950-51 and 1951-52 as compared with 1952-53, but that during the winter of 1949-50 some other factor was active. A study of Figure 3 indicates that a relatively high volume of bitterbrush forage was taken by

deer from only a medium supply in 1949-50. This resulted in the highest percentage utilization by deer (42 percent) recorded in the study. It may be, as suggested by Lassen et al. (1952), that the shortage of green herbaceous feed during that dry, cold winter forced deer to browse bitterbrush heavier than would be expected from the pressure index relationships.

Relation of Bitterbrush Utilization to Succeeding Fawning Success

In order to determine if a relationship exists between winter bitterbrush utilization and the success of the succeeding season's fawning (as indicated by fall doe:fawn ratios), the data were assembled as shown in Table 12. It was found that an apparent relation existed, although in this instance there appears to be a somewhat better correlation with total percentage utilization than with utilization by deer alone. The relation of fawn success to total bitterbrush cropping is shown in Figure 5. This appears to strengthen the evidence that after a winter of nutritional deficiency (as evidenced by their need to crop bitterbrush heavily) deer are less successful in fawning than where the opposite is true. Here again the importance of maintaining proper balance between deer numbers and forage supply becomes evident.

TABLE 12

Relation of Bitterbrush Utilization to Success of Succeeding Season's Fawning

Year	Percentage bitterbrush utilization		Fawns per 100 does	
	By deer	Total	Year	Fall ratio
1949-50	42	67	1950-51	49
1950-51	34	62	1951-52	64
1951-52	39	57	1952-53	65
1952-53	25	49	1953-54	77

Unfortunately, it is not possible at this time to check the findings of the four-year study against data from other similar deer ranges in this State. There is a lack of spring fawn survival data from other areas. Survival records for the past two years only are at hand from four other deer range studies. But on all of these ranges, deer were forced out of bitterbrush zones by heavy snows during the winter of 1951-52 and had to subsist for much of the time on marginal areas. As a consequence, fawn survival in these herds was low and out of all proportion to that which would be indicated by percentage bitterbrush utilization. It is highly desirable that the findings of the Lassen-Washoe study be checked against data from other similar deer ranges.

CONCLUSIONS

The findings of this four-year study indicate a strong correlation between fawn survival and percentage utilization of bitterbrush leader growth by deer on the Lassen-Washoe winter range. The relationships found here give support to the belief that bitterbrush can serve as an indicator species in management of the deer herd. The studies make

TABLE 13

Statistical Data on Bitterbrush
(Statistical Means at the 5 Percent Level)

Year	Number of plots	Number of plants	Percentage utilization	
			Fall	Spring
1949-50	67	181	25.4±4.2	67.4±4.0
1950-51	92	272	26.6±5.6	64.1±4.2
1951-52	114	361	17.8±3.6	57.6±3.4
1952-53	124	419	22.6±4.3	48.1±3.9

Percentage of ground covered by living bitterbrush: 2.75 ± 0.36.

it appear that, under the existing demand for bitterbrush by livestock, a moderate decline in fawn survival may be expected where the cropping of bitterbrush leader growth by deer exceeds 25 percent, and a steep decline where it exceeds 34 percent. Were livestock demand changed, this percentage relationship, no doubt, would shift. It would appear, under existing conditions, that deer browsing should not be much above the 25 percent bitterbrush utilization level for good sur-

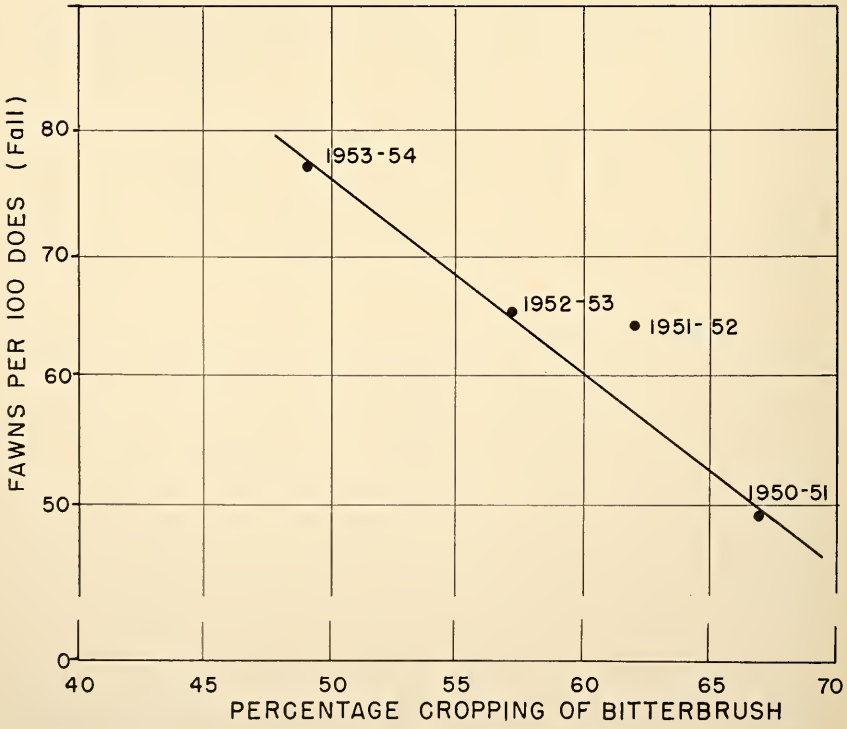

FIGURE 5. Relation of percentage bitterbrush utilization to following season's fawn success.

vival of the fawns of the year and good success of fawning during the succeeding season.

The generally consistent relationships found in this study indicate that the survey methods used can provide data which are adequate for deer management purposes.

SUMMARY

1. A range investigation has been in progress for four years in conjunction with Rocky Mountain mule deer (*O. h. hemionus*) herd studies on the Lassen-Washoe interstate winter deer range. The study is under the direction of the Lassen-Washoe deer herd study committee.
2. A ground cover inventory, made with line-point plots, reveals that vegetation available to deer and livestock covers 32.1 percent of the ground surface. Browses cover 20.1 percent of the ground surface. Sagebrush is the most abundant browse, followed by bitterbrush, rabbitbrush, desert peach, horsebrush, and juniper.
3. An age class index compiled from range plot data indicates that there is little replacement by bitterbrush reproduction of the dead and dying browses on the range. Over 43 percent of the bitterbrush shrubs checked were classified as decadent.
4. The form class index shows that 78.8 percent of the bitterbrush plants checked were classed as heavily hedged, as a result of past overbrowsing.
5. Deer pellet group counts ranged from 236 groups per acre during the winter of 1952-53 to 438 groups per acre during the winter of 1951-52.
6. Forage utilization studies reveal that bitterbrush is by far the most heavily cropped browse on the winter range. Use by deer, livestock, and rodents has ranged from an average of 67 percent in 1949-50 to 49 percent in 1952-53.
7. The volume of bitterbrush growth produced has varied from year to year, as indicated by average leader lengths. The length of average bitterbrush leaders ranged from 3.1 inches in 1950-51 to 5.1 inches in 1951-52.
8. There has been extreme variation in fawn survival, as shown by spring composition counts. Fawns per 100 does in April have ranged from 12 in 1949-50 to 64 in 1952-53.
9. Analysis of the various range data, together with the fawn survival figures, reveals a strong relationship between percentage utilization of bitterbrush by deer and fawn survival.
10. The volume of bitterbrush forage taken by livestock appears to have been constant over the last four years, although percentage utilization shows considerable variation. The effect of the impact of livestock use on fawn survival appears to have remained constant during the study. The volume of bitterbrush forage taken by deer shows considerable variation from year to year.

11. The data indicate that bitterbrush consumption rose and fell, and fawn survival went up and down, with total range pressure by deer (as reflected by pellet groups per acre) except during the winter of 1949-50. In that year, fawn survival was extremely low and bitterbrush utilization extremely high, and both of them out of all proportion to total deer pressure.
12. A relationship appears to exist between intensity of bitterbrush cropping and the success of the succeeding season's fawning, as reflected in fall doe:fawn ratios.
13. The study has provided support for the belief that bitterbrush is an indicator species of value in deer management on the Lassen-Washoe range.
14. It is planned to check the validity of these findings against data from similar ranges. Meanwhile, they can stand as an example of how range data may be used to guide deer management.

The findings indicate that the survival of the fawns of the year and the success of the following season's fawning are dependent upon the deer not browsing much above the 25 percent bitterbrush utilization level. This is true under the existing level of livestock pressure on the Lassen-Washoe range.

LITERATURE CITED

Aldous, C. M.
1945. A winter study of mule deer in Nevada, Jour. Wildlife Mangt., vol. 9, no. 2, p. 145-151.

Blaisdell, James A.
1953. A progress report on the Doyle Deer Herd. West. Assoc. St. Game and Fish Comm., 33d Ann. Conf., Proc. (In press.)

Dasmann, William P.
1947. A critical review of range survey methods and their application to deer range management. Calif. Fish and Game, vol. 34, no. 4, p. 189-207.
1951. Some deer range survey methods. Calif. Fish and Game, vol. 37, no. 1, p. 43-52.

Hormay, A. L.
1943. A method for estimating grazing use of bitterbrush. Calif. Forest and Range Expt. Sta., Research Note no. 35, 4 p.

Interstate Deer Herd Committee
1951. The Devils Garden deer herd. Fifth progress report of the interstate deer herd and its range, including a summation of work to date. Calif. Fish and Game, vol. 37, no. 3, p. 233-272.

Lassen, R. W., C. M. Ferrel, and Howard Leach
1952. Food habits, productivity and condition of the Doyle mule deer herd. Calif. Fish and Game, vol. 38, no. 2, p. 211-224.

Lomasson, T., and Chandler Jensen
1942. Determining the utilization of range grasses from height-weight tables. U. S. Forest Serv., Northern Region, 9 p. (Mimeo.)

Parker, Kenneth W.
1942. A method for estimating grazing use in mixed grass types. Southwest Forest and Range Expt. Sta., Research Note no. 35, 5 p. (Mimeo.)
1951. A method for measuring trend in range condition on national forest ranges. U. S. Forest Serv., 26 p. (Mimeo.)
1953. Instructions for measurement and observation of vigor composition and browse. U. S. Forest Serv., 9 p. (Mimeo.)

EIGHTH PROGRESS REPORT ON THE COOPERATIVE STUDY OF THE DEVILS GARDEN INTERSTATE DEER HERD AND ITS RANGE[1]

INTERSTATE DEER HERD COMMITTEE

INTRODUCTION

The Interstate Deer Herd Committee was organized in 1945 to study the Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) problem on the Devils Garden winter deer range in Modoc County, California, and to attempt to draw up a plan for management. The committee is composed of members of the Oregon Game Commission, the U. S. Forest Service (Regions V and VI), and the California Department of Fish and Game. Representatives of organized sportsmen and of livestock growers' associations are invited to committee meetings to act in an advisory capacity. This is the first instance of such a cooperative venture in California to study a deer herd and its range. This pilot study has helped in developing deer and range survey techniques and management practices that have later been used successfully in other parts of the State.

During the past eight years, the committee has fostered the following investigations: (1) deer herd collections to determine general condition, disease, parasites, productivity, and food habits; (2) road kill collections for the same purpose; (3) trapping and marking; (4) predator control; (5) wild horse removal; (6) livestock use reduction; (7) antlerless deer removals; (8) salting experiments; (9) deer herd composition counts; (10) trials of census methods; (11) carcass counts; (12) annual forage utilization checks; (13) range trend inventories; (14) range reseeding; (15) habitat improvement work; and (16) range revegetation studies.

Throughout the investigation, numerous problems have arisen which have resulted in a change of the methods used to gather the information needed for management. For instance, when forage plots were first installed, an attempt was made to get a coverage of the entire winter range. This forage utilization study revealed that deer browsing was heaviest on areas where winter concentrations occurred and that forage use was relatively light on areas principally used during migration. This changed the concept of management from one embracing an extensive range to one of primary concern with a key area on which the deer tend to concentrate during the winter months. It was premised that if the better deer forages could be maintained on the key area, where cropping is ordinarily heaviest, the rest of the range would logically take care of itself. The key management area embraces the range on

[1] Submitted for publication December, 1953. Special acknowledgment is made of the work of Trevenen Wright of the California Department of Fish and Game, who did a large share of the compilation of this report.

which deer use is concentrated during mid-winter and on which an adequate supply of forage is vital to maintenance of the deer herd.

FIRE HISTORY

Fires in the Great Basin area are generally deterimental to deer browse species, because most of these shrubs do not sprout after burning. Fire usually results in destruction of browse, and their replacement by annuals, such as cheat grass (*Bromus tectorum*). This results in an increase in the fire hazard; a vicious circle, since dry cheat grass is more combustible and carries fire more quickly than will the native perennials. Cheat grass also offers stiff competition for living space to the more desirable forage species.

One of the problems on the winter range of the Devils Garden interstate deer herd is the destruction of valuable browse stands by the several large fires which have occurred since 1936. The location of these fires is shown in Figure 1. The most recent extensive burn, the Mears fire, occurred in 1951. This fire covered nearly 27,000 acres in the heart of the winter range. Nearly one-fifth of the key management area was burned, including extensive stands of bitterbrush (*Purshia tridentata*), an important winter deer browse.

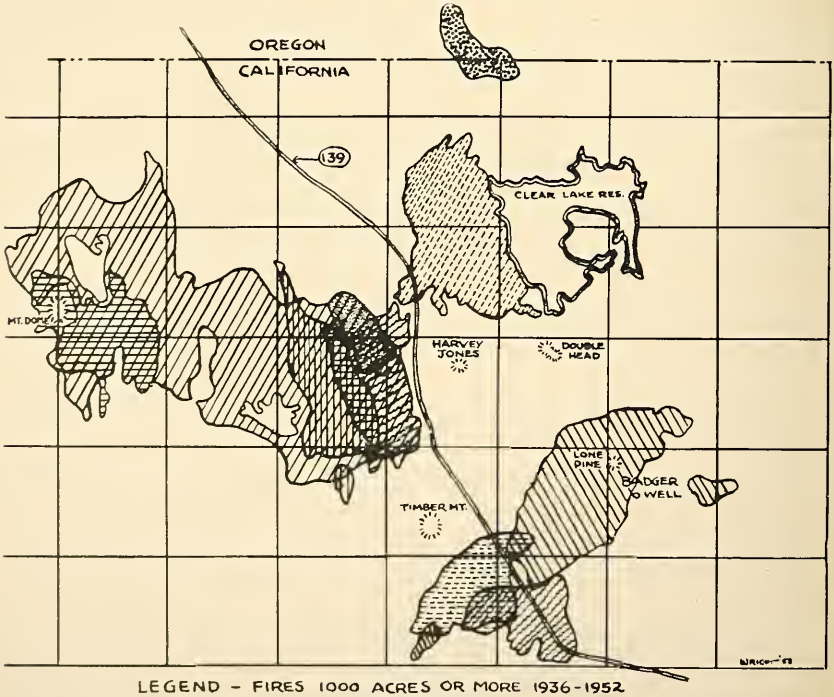
OREGON
CALIFORNIA
139
CLEAR LAKE RES.
MT. DOME
HARVEY JONES
DOUBLE HEAD
LONE PINE
BADGER WELL
TIMBER MT.
LEGEND - FIRES 1000 ACRES OR MORE 1936-1952
1936 - CORNELL 21,090 ACRES
1938 - HOSPITAL ROCK, LAVA BEDS 17,087
1940 - BRYANT MT. 1,019
1941 - MAMMOTH, BARN TOP 97,780
1944 - TWIN SISTERS, MT. DOME 17,695
1945 - DAMON BUTTE 12,110
1946 - TWIN SISTERS 5,882
1948 - MUD LAKE 1,016
1950 - MAMMOTH, PUMICE MILL, PLUM RIDGE 23,760
1951 - MEARS, MOWITZ 26,858

FIGURE 1. Fire history map, Devils Garden winter deer range.

SIZE OF THE DEER HERD

Track Count

Although various techniques and methods have been used to determine the size of the deer population which winters on the Devils Garden range (Interstate Deer Herd Committee, 1951), none have proved as satisfactory as the state line track count. This track count has been carried on each spring for the past seven years. Only the interstate herd which migrates from California into Oregon is inventoried by the track count. This count does not account for the deer which migrate from the Devils Garden area to summer ranges in California. The population figures obtained from this count are therefore considered conservative.

Early in the spring, when observations indicate the deer herd is migrating north, an airplane is used to determine the proximity of deer to the state line. When deer begin to cross the state line road, the counters move in with jeep, horses, and equipment. Camp is made near the state line, in a U. S. Forest Service cabin.

The length of the track counting-strip is approximately 23 miles. It runs from Willow Reservoir in Klamath County, Oregon, to Young Valley in Lake County, Oregon.

The track counting-bed is approximately 36 inches wide, a width sufficient to record the tracks of walking or trotting deer. The average walking step of the adult deer is 18 inches, while the trotting step averages 28 inches. Very few deer run across the counting-bed, because there is little to disturb them.

The counter walks in front of the jeep with a tally register in each hand and tallies the north- and southbound tracks. At the end of the strip, the south tracks are subtracted from the north and the actual number of deer going north is recorded.

Half of the strip is counted every other day. A crew of two men handles the count. Horses are used, when snow and road conditions are poor, to count deer crossings and reconnoiter roads for travel. Herd composition is tallied at the same time the count is in progress. Fawn losses over the winter can then be calculated.

As the count is made, the tracks are erased and the track-bed prepared for the next count by the jeep, which pulls a spring-toothed harrow and a tire behind the counters (Figure 2). This operation is carried on every day until the northward migration diminishes, after which counts are made at longer intervals.

Conditions which tend to bring about a conservative count include (1) stretches of rocky and hard road surfaces; (2) snow and rain, which cover or wash out tracks; (3) single-file crossing of large groups of deer, which results in obliterating tracks; (4) livestock on track-bed, which obliterate tracks; (5) deer crossing on snow packs which subsequently melt way; (6) deer crossing on wet ground that is frozen; and (7) incidental vehicles which travel on the track-bed.

Table 1 shows the actual count figures and the estimated population for the past seven years of the count. Table 2 shows the number of deer counted by weeks.

TABLE 1

State Line Track Count Figures for Seven Years

Year	Actual tally	Estimated missed*	Adjusted total
1947	10,826	2,060	12,886
1948	9,665	------	------
1949	14,011	------	------
1950	13,256	2,000	15,256
1951	17,570	2,000	19,570
1952	10,547	1,500	12,047
1953	11,601	3,000	14,601

* These estimates are derived from field observations. They include deer crossing before and after track counting period, deer crossing during storms, and those crossing rocky places in the track bed.

Pellet Count

Each spring when the forage utilization check is made, groups of deer droppings are counted on tenth-acre strips, 11 chains long and six feet wide. The pellet group count is converted into deer days by use of a conversion factor of 12.7 groups per deer day, as determined by Rasmussen and Doman (1943).

In the past, pellet group counts were used by the committee to estimate the deer population. Now that only the key management area is sampled each year, the pellet count is used as an indicator of the trend in deer use on that area.

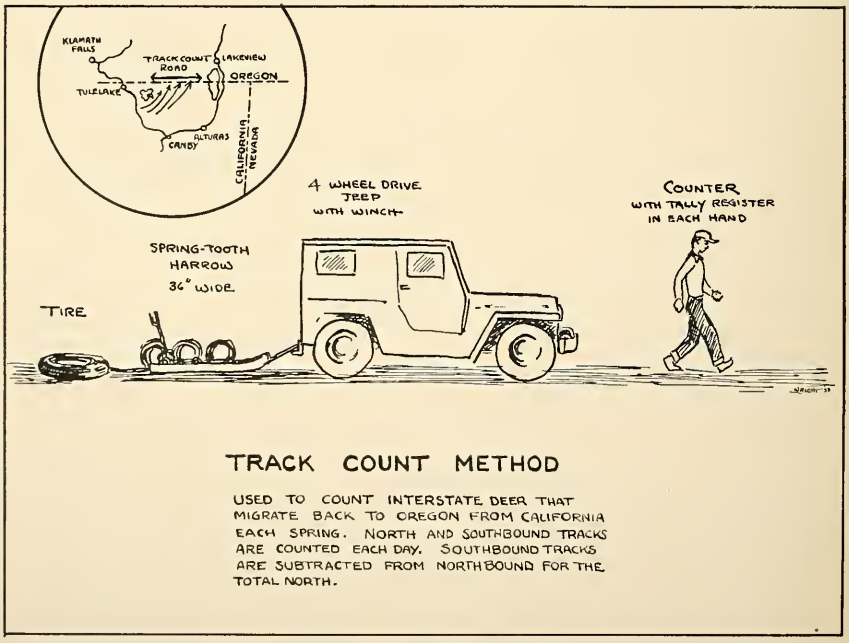
KLAMATH FALLS
TRACK COUNT ROAD
LAKEVIEW
OREGON
TULELAKE
ALTURAS
CANBY
CALIFORNIA
NEVADA
4 WHEEL DRIVE JEEP WITH WINCH
COUNTER WITH TALLY REGISTER IN EACH HAND
SPRING-TOOTH HARROW 36" WIDE
TIRE
TRACK COUNT METHOD
USED TO COUNT INTERSTATE DEER THAT MIGRATE BACK TO OREGON FROM CALIFORNIA EACH SPRING. NORTH AND SOUTHBOUND TRACKS ARE COUNTED EACH DAY. SOUTHBOUND TRACKS ARE SUBTRACTED FROM NORTHBOUND FOR THE TOTAL NORTH.

FIGURE 2. Track count procedure.

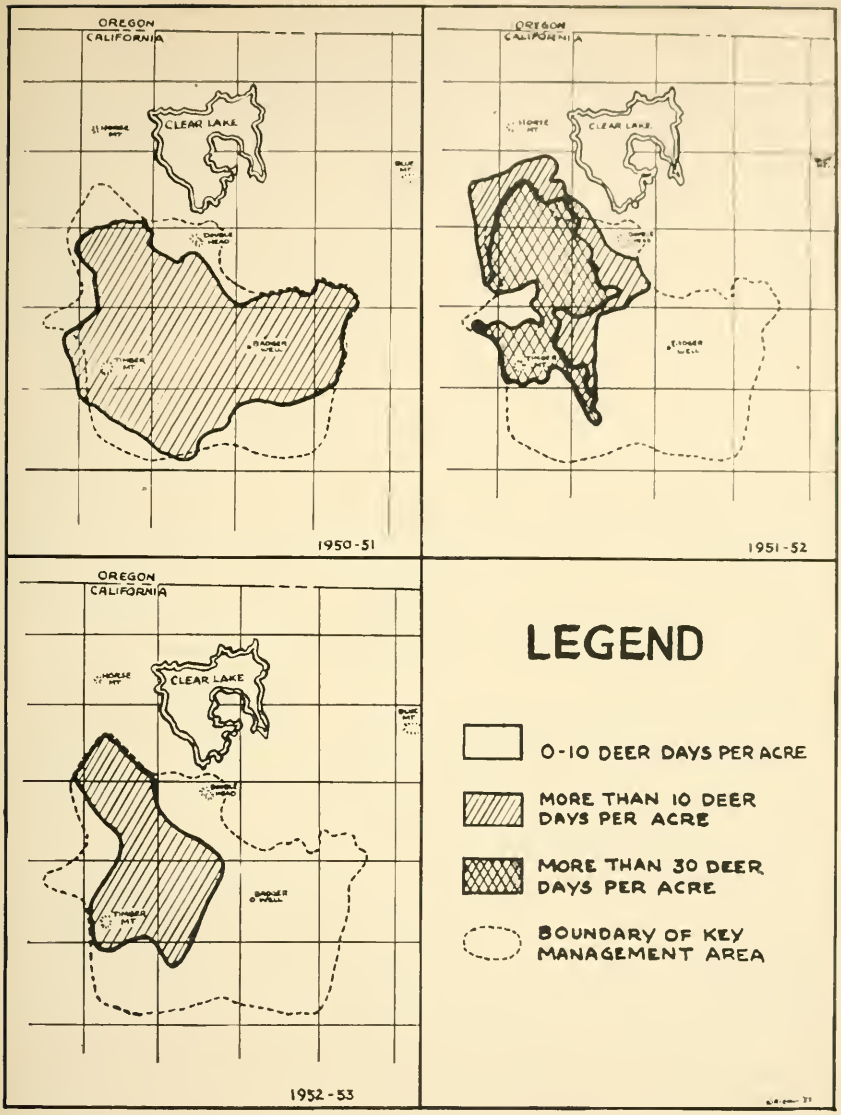

FIGURE 3. Deer concentration areas according to pellet count data.

Figure 3 delineates the portion of the winter range on which deer were most concentrated during three winters (1950-51, 1951-52, 1952-53), as shown by abundance of pellet groups. Table 3 shows average pellet group counts and deer days use per acre for the three winters on the management area.

TABLE 2

State Line Track Count, by Weekly Periods

Year	April 5–11	April 12–18	April 19–25	April-May 26–2	May 3–9	May 10–16	May 17–23	May 24–30	May-June 31–6
1947	2,566	4,560	3,030	670					
1948		94	577	730	3,241	3,616	754	653	
1949			5,808	3,614	3,323	902	364		
1950	970	801	2,329	4,574	1,300	2,482	800		
1951	6,226	5,485	4,134	888	95	606	136		
1952		364	1,551	3,316	3,394	1,711		211	
1953	*2,954	1,104	2,893	1,411	2,492	428	143		176

* Tracks counted February 17th to April 11th, inclusive.

THE COMPOSITION OF THE DEER HERD

During the winter of 1952-53, the composition count of animals in the Interstate and Glass Mountain deer herds was made from the middle of November to the end of December. Similar methods of classification were used as in past years (Interstate Deer Herd Committee, 1951). For classification purposes the western limit of the Interstate deer range is arbitrarily set at the Great Northern Railroad track. There is some intermingling of Interstate and Glass Mountain deer along this line. Table 4 gives the herd percentages for the past ten winters of the study.

As seen in Table 4, the percentage of fawns in the herd in 1953 is down from previous years but is still high, considering the heavy die-off during the preceding winter. This may be due in part to the decreased number of yearling (non-bearing) does in the count, resulting from deer loss as fawns the previous winter.

Table 5 shows the buck-doe and fawn-doe ratios for the past ten years of the study.

The number of bucks per 100 does has remained relatively low in the Interstate herd, because of heavy hunting pressure and because of the vulnerability of the deer, due to the openness of the country. Apparently the incidence of pregnancy has remained satisfactory in spite of the wide ratio, as evidenced by the doe-fawn ratio, which has remained as high as in most other herds in California.

TABLE 3

Average Pellet Groups Per Plot and Deer Days Use

Year	Average groups per plot	Deer-days per acre
1950-51	30.9	24.3
1951-52	22.1	17.4
1952-53	13.2	10.4

TABLE 4

Herd Percentages for Past 10 Years of Study

Year	Bucks	Does	Fawns	No. deer classified
1943-44	9	63	28	5,986
1944-45	8	55	37	3,007
1945-46	6	61	33	1,696
1946-47	9	57	34	1,603
1947-48	8	59	33	1,736
1948-49	5	59	41	297
1949-50	8	17	45	1,835
1950-51	10	51	39	1,564
1951-52	7	52	41	1,061
1952-53	7	60	33	1,019

Table 6 shows the antler point classes of the bucks classified during the past several years.

It can be noted from Table 6 that the percentage of spike bucks has been increasing gradually each year, with only two exceptions. The 1952-53 decline can be explained by the winter die-off which took a heavy toll of fawns in 1951-52. On deer ranges in good condition, the Rocky Mountain mule deer reportedly is a forked horn the first year.

TABLE 5

Buck-Doe and Fawn-Doe Ratios

Year	Bucks per 100 does	Fawns per 100 does
1943-44	14	45
1944-45	15	67
1945-46	10	54
1946-47	16	61
1947-48	14	56
1948-49	10	85
1949-50	17	94
1950-51	19	77
1951-52	13	77
1952-53	12	55

TABLE 6

Antler Point Classes, by Percentage

Year	Number of points					Number of bucks classified
	1	2	3	4	Over 4	
1943-44	5	30	30	28	7	515
1944-45	9	28	25	34	4	240
1945-46	8	26	26	38	2	109
1946-47	10	25	22	30	13	144
1947-48	19	40	17	18	6	141
1948-49	25	31	19	12.5	12.5	16
1949-50	29	42	12	14	3	154
1950-51	36	31	20	9	4	154
1951-52	36	26	19	16	3	73
1952-53	21	32	24	17	6	71

Antler growth seems definitely correlated with good nutrition. The increase in spikes on the Interstate winter range may be due directly to a deterioration of range conditions.

WINTER MORTALITY

The winter of 1951-52 was a deep snow winter and the conditions caused a heavy toll of deer on most of the poorer winter ranges in northeastern California. One of the heaviest hit herds was that on the Devils Garden. The calculated loss of this herd was approximately 32 percent.

The first indication of an impending winter loss was the general condition of deer seen the last of December. It was noted that instead of "kegging up" during storms, the animals were feeding right through the day. Deer began invading the Tulelake Homesteads for the first time, feeding from haystacks and new alfalfa seedings. Nine deer, killed on the railroad tracks January 28 near Perez, were all in poor condition. A trip was made in the vicinity of Dead Horse Canyon January 31. A total of 536 deer was seen and approximately 20 percent of them were in extremely poor condition. One dead fawn was found.

The snow depth level in the die-off area never exceeded two feet, and was generally considerably less. During the first part of February the weather was clear and mild and this encouraged the growth of grass. The deer started feeding on this grass out in the flats. Snow storms occurred immediately afterwards and continued through the following month. As a consequence, the deer moved back to the juniper thickets and protective rims, where most of the carcasses were later found.

Sportsmen's Feeding

Sportsmen in Tulelake, California, hearing reports about dead deer (which were plainly visible from State Highway 139), became alarmed. On February 23, these sportsmen took six tons of feed and salt out to the deer. The feed consisted of cottonseed cake and range pellets (40 percent protein). The deer used the feed but not much of the salt. Whether this feeding resulted in the saving of deer was not determined. There were many carcasses in the vicinity of the feeding stations, but these animals could have died prior to provision of feed. The peak of the die-off occurred in the middle of February, before feeding commenced.

Stomach Contents

A collection of 110 stomachs from winter-killed deer was taken to the department's Food Habits Laboratory and the stomach contents analyzed. Table 7 shows stomach analysis of 55 deer collected in the Casuse Mountain locality and Table 8 shows the analysis of 44 stomachs taken in the Sagehorn vicinity. It should be stressed that the tables indicate the diet of deer which were not able to withstand the winter.

The stomachs of all deer, with the exception of two fawns, were full. Although even in mild winters some juniper is utilized, it is apparent from the tables that a diet heavy in juniper will not maintain these animals under conditions similar to those of the winter of 1951-52.

TABLE 7

Food Items Eaten by 55 Winter-killed Deer Near Casuse Mountain

Common name	Volume percent	Frequency of occurrence in percent
Browse		
Juniper	54.0	100
Sagebrush	15.0	91
Rabbitbrush	1.3	24
Bitterbrush	trace	4
Total browse	70.3	
Forbs		
Rock lichen	0.6	15
Tumbling mustard	0.3	24
Moss	trace	33
Filaree	trace	2
Forbs spp. (dry stems)	trace	7
Total forbs	0.9	
Grass		
Grass (dry)	26.8	91
Grass (green)	2.0	71
Cheat grass (dry florets)	trace	67
Total grass	28.8	

TABLE 8

Food Items Eaten by 44 Winter-killed Deer Near Sagehorn

Common name	Volume percent	Frequency of occurrence in percent
Browse		
Juniper	54.4	100
Sagebrush	8.0	64
Rabbitbrush	1.4	25
Total browse	63.8	
Forbs		
Tumbling mustard	1.8	25
Rock lichen	trace	7
Moss	trace	9
Filaree	trace	7
Total forbs	1.8	
Grass		
Grass (dry)	30.7	93
Grass (green)	3.7	66
Cheat grass	trace	73
Total grass	34.4	

The heaviest mortality occurred in an area which has been gutted by fires in past years, thus offering little in the way of adequate forage for deer. Practically 100 percent of the junipers on this area are now highlined as high as an adult deer can reach.

Bone Marrow

Another check on the condition of the animals was made by examining the bone marrow in the femur of 122 deer. According to Cheatum (1949) the bone marrow of the deer can be used as an index of malnutrition. As an animal declines in physical condition, the bone marrow reportedly changes in color and consistency. The following four bone marrow classifications were used: (1) solid, white marrow: excellent condition; (2) solid, red-flecked marrow: good condition; (3) fairly solid, red marrow: fair condition; (4) jelly-like, red marrow: poor condition. Of the 122 animals checked for bone marrow condition, all but five were found to be in the fourth category.

Carcass Composition Count

A total of 708 deer carcasses were classified as to age and sex. It was found that 16.6 percent were adults, 5.8 percent were yearlings, and 77.6 percent were fawns. Ninety percent of the deer were found lying beneath junipers, many as if they had lain down to sleep. Approximately 10 percent of the adults were old deer that may have died regardless of winter conditions. Table 9 shows a further breakdown of the composition of the carcass count.

Dentition was used to classify the yearling class from older deer. The dentition of yearlings examined showed only partially erupted canines and the third premolars not yet replaced by permanent teeth.

TABLE 9

Composition of 1951-52 Winter-killed Deer on Devils Garden Interstate Winter Range

Animal class	Number classified	Percent of total
Adults		
Female	103	14.6
Male	14	2.0
Total adults	117	16.6
Yearlings		
Female	23	3.3
Male	18	2.5
Total yearlings	41	5.8
Fawns		
Female	299	42.2
Male	251	35.4
Total fawns	550	77.6
All deer	708	100.0

Predation

Evidence of predation was found in approximately 5 percent of the carcasses. How much was due to the animals being in poor and weakened condition was difficult to evaluate. A number of the carcasses examined had been eaten after the deer had died. Eagles had worked on rib cages and eaten viscera, while pack rats had hollowed out hams and eaten ears, noses, and feet.

Carcass Count

Between April 20 and May 2, 1952, the dead deer were counted in an area of 38,575 acres (Figure 4). A map of the die-off area was drawn

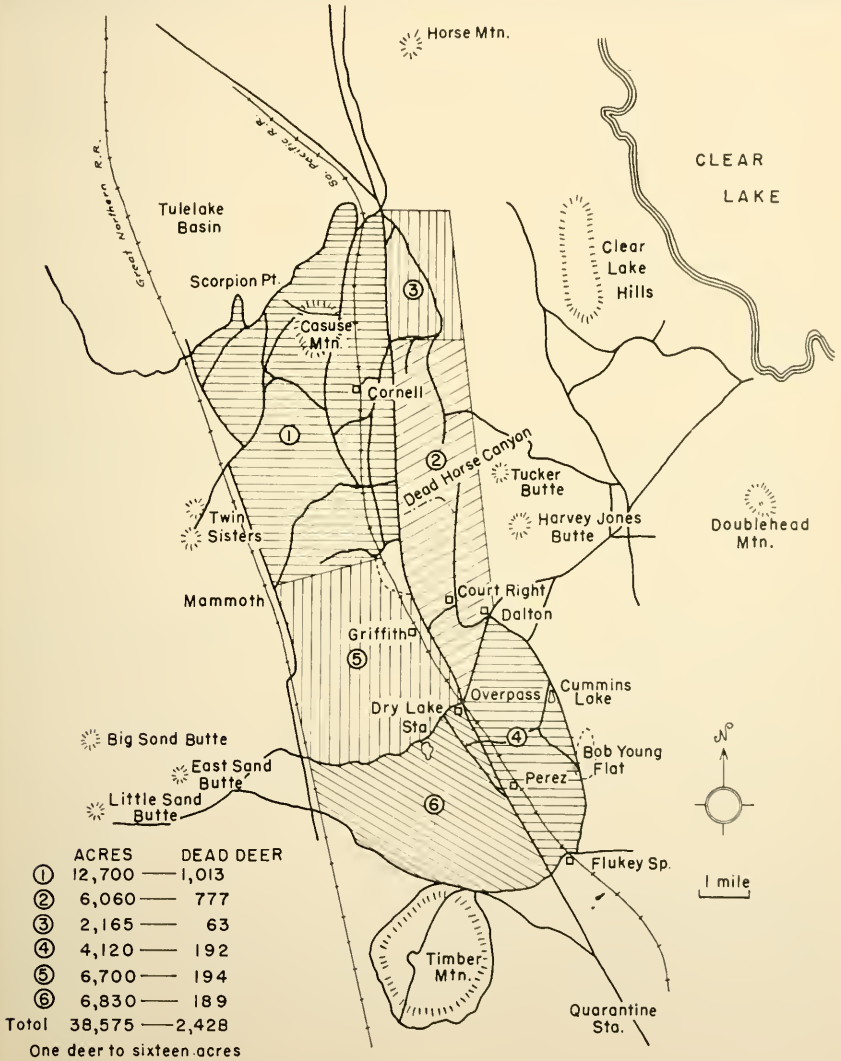

FIGURE 4. Carcass count areas, Devils Garden winter deer range. Counts made April 20, 21, 22, 29, 30, and May 1 and 2, 1952.

from previous reconnaissance and divided into six units. Manpower and time limited the counting and 100 percent coverage could not be attained on any one unit, although on Unit 3 the coverage amounted to an estimated 90 percent, since men were walking within sight of each other during the whole count (150 yards apart, estimated).

As mentioned before, most of the deer died under junipers. It was therefore possible to walk by a dead deer without seeing it. As an example: one counter who had a dog looked back to see the dog sniffing a carcass by which he had walked within 15 yards, and had not seen.

Road kills, fence kills, and railroad kills were excluded from the count. A rock was placed on each carcass as it was counted to avoid duplication.

TABLE 10

Unit Data of Carcass Count (see Figure 4)

Unit	Date	Acreage	Man days	Total count	Acres per deer	Estimated coverage (percent)	Deer
1	4/20	12,700	20	1,013	12.5	70	1,447
2	4/21	6,060	14	777	6.8	75	1,036
3	4/22	2,165	7.5	63	34.4	90	70
4	4/29	4,120	8	192	21.5	85	226
5	4/30	6,700	9	194	34.5	85	228
6	5/1–2	6,830	10	189	56.0	80	236
Totals		38,575	68.5	2,428			3,243

A total of 68½ man-days was expended on the tally. Besides personnel from the three agencies concerned with the study, assistance in the count was given by the Klamath Falls Sportsmen's Association.

A total of 2,428 deer was counted on 38,575 acres, or one deer to every 16 acres. The estimated total loss on the count areas was estimated to be 3,243 deer, or one deer to every 12 acres. As only the heavily concentrated areas were counted and deer also died along the migration routes to Oregon, the total number of animals lost on the winter range was considerably greater than the total estimated to have died on the count area.

Unit 2 produced the most carcasses per acre, with one deer for every 6.8 acres. Unit 1 was next, with one deer for every 12.5 acres.

The mild winter of 1952-53 caused very little mortality and, except for normal loss due to old age, survival was high.

DEER COLLECTION

For the past three years, highway-, fence-, and railroad-killed deer have been collected during the winter and spring. Arrangements were made with the Quarantine Station, Division of Highways and Highway Patrol, to notify the California Department of Fish and Game in Alturas whenever any deer were found. The deer were then aged, sexed,

measured for girth, checked for condition, lactation, pregnancy, embryo sex and size, parasites, and disease. Stomach samples and ovaries were collected. Table 11 gives a summary of some of these data.

Carcasses not too badly damaged were given to the Modoc County Jail.

TABLE 11

Summary of Highway-, Fence-, and Railroad-killed Deer

	1951	1952	1953
Number of deer examined	30	59	40
Adults			
Female	11	26	19
Male	1	2	0
Yearlings			
Female	0	9	2
Male	2	1	3
Fawns			
Female	7	7	9
Male	7	9	7
Unclassified	1	5	0
Number does examined for pregnancy	11	18	9
Percent pregnancy	88	67	100
Number embryos per doe	1.75	1.0	1.6
Bone marrow condition in percentage			
Number 1—excellent—solid, white		18	36
Number 2—good—solid, fleeked red		43	52
Number 3—fair—solid, all red		26	12
Number 4—poor—jelly, all red		13	0

FORAGE STUDIES

Forage Inventory Report

In 1947 and 1948, 400 line-intercept sample range plots were installed on the Devils Garden winter deer range. These plots were established at predetermined intervals along, but at right angles to, the many roads and trails that traverse the winter range. Plots were 200 feet long. Plant measurements were taken along 500 inches of this line. The 500 inches were broken into 20 segments, each 25 inches long. These segments were spaced along the transect line at 10-foot intervals. The individual segments were marked by painted 60-penny spikes. Transects were marked at roadsides with numbered iron posts. An analysis of the plot data was made to determine the composition of the ground cover on the key management area. A total of 204 plots fell inside the area. From these, it was computed that, if all forage species were evenly spread over the management area, the surface of every thousand acres would be covered as shown in Table 12.

In the fall of 1952, 105 of the sample plots in the key area were remeasured. The survey was made to determine if changes had occurred during the four-year period. Of the plots remeasured, 90 were converted to the line point method, which is now the standard method used throughout the State in open type deer range studies. Bitterbrush, juniper, sagebrush, and rabbitbrush plants on the plots were classified as to form and age classes, to gain information on availability, hedging, and age of these browses. Data from the 90 line point plots are compared below with those from the 90 line intercept plots to point out the differences in results from the two methods.

TABLE 12

Forage Cover on Key Management Area

Class of cover	Acres	
Bare ground	291	
Rock	55	
Litter	298	
Dead bitterbrush	18	
Dead sagebrush	13	
Other dead browses	5	
Total nonproductive		680
Annual grasses	45	
Annual forbs	34	
Total annuals		79
Mosses	2	
Sedges	14	
Perennial grasses	70	
Perennial forbs	22	
Total perennial herbs		108
Bitterbrush	29	
Juniper	4	
Rabbitbrush	14	
Sagebrush	67	
Squaw carpet	12	
All other available browses	6	
Total browses		132
Unclassified cover	1	1
Grand total		1,000

In presenting the range sample plot data, four comparisons have been made to show the different methods of analysis. The first comparison (Table 13) shows the number of inches of various classes of cover measured in 1948 in comparison with the number of inches measured in 1952. This is a yardstick from which actual changes in the ground cover are indicated. Table 14 shows the percentage composition of the living vegetation. Table 15 gives the number of plots on which each class of cover occurred. Table 16 shows the number of segments that contained plants in 1948, in comparison with 1952.

In comparing the ground cover data, some differences should be explained. For example, the percentage of rock increased in the 1952 breakdown. This can be attributed to the fact that fires uncovered rock that formerly was covered with vegetation.

TABLE 13

Comparative Analysis of Ground Cover in Key Area for 1948 and 1952
(Based on 105-line transect plots, 52,500″ of intercept)

Ground cover	1948		1952	
	Inches	Percent	Inches	Percent
Bare soil	14,509	27.6	11,286	21.5
Rock	2,620	5.0	2,923	5.6
Litter	16,928	32.2	18,158	34.6
Moss	106	0.2	95	0.2
Dead sagebrush	725	1.4	848	1.6
Dead rabbitbrush	205	0.4	194	0.4
Dead bitterbrush	1,344	2.6	866	1.6
Dead others	15	0.0	113	0.2
Total nonproductive	36,452	69.4	34,483	65.7
Annual grasses	1,696	3.2	4,310	8.2
Annual weeds	1,246	2.4	2,829	5.4
Total annuals	2,942	5.6	7,139	13.6
Sagebrush	2,583	4.9	1,535	3.0
Squaw carpet	755	1.4	1,050	2.0
Rabbitbrush	712	1.4	618	1.2
Juniper	290	0.6	583	1.1
Yellow pine	148	0.3	174	0.3
Wild cherry	68	0.1	112	0.2
Bitterbrush	2,451	4.7	1,945	3.7
Other shrubs	47	0.1	110	0.2
Total browse species	7,054	13.5	6,127	11.7
Balsam root	499	0.9	164	0.3
Mule-ear	313	0.6	145	0.3
Other forbs	230	0.4	138	0.2
Total perennial forbs	1,042	1.9	447	0.8
Bluebunch wheatgrass	198	0.4	222	0.4
Sedge	935	1.8	710	1.4
Idaho fescue	419	0.8	266	0.5
Junegrass	64	0.1	48	0.1
Bluegrass	1,188	2.3	652	1.2
Squirreltail	1,077	2.0	920	1.8
Needlegrass	1,083	2.1	1,431	2.7
Other perennial grasses	46	0.1	55	0.1
Total perennial grasses	5,010	9.6	4,304	8.2
Grand totals	52,500	100.0	52,500	100.0

The dead sagebrush category shows an increase in 1952, while dead bitterbrush shows a decrease. At the same time, losses of coverages by living plants have been sustained for both species. In the case of dead sagebrush, the increase was due to plants dying from causes other than fire. The decrease in the amount of dead bitterbrush was mostly due to fire, which completely consumed the dead shrubs.

Annual grasses and weeds show increases due, for the most part, to fire.

TABLE 14

Comparative Analysis of Vegetative Composition by Percentage
(Based on 105-line transect plots, 52,500″ of intercept)

Plant species	1948	1952
Sagebrush	16.10	8.52
Squaw carpet	4.70	5.83
Rabbitbrush	4.44	3.43
Juniper	1.81	3.24
Yellow pine	.92	.97
Wild cherry	.42	.62
Bitterbursh	15.27	10.79
Others	.30	.61
Total shrubs	43.96	34.01
Annual grasses	10.57	23.92
Bluebunch wheatgrass	1.23	1.23
Sedge	5.83	3.94
Idaho fescue	2.61	1.48
Junegrass	.39	.27
Bluegrass	7.40	3.62
Squirreltail	6.71	5.11
Needlegrass	6.75	7.94
Others	.30	.30
Total grasses	41.79	47.81
Annual weeds	7.76	15.70
Balsam root	3.11	.91
Mule-ear	1.95	.80
Others	1.43	.77
Total forbs	14.25	18.18
Grand total	100.00	100.00

In the perennial grasses a decrease is shown in all species with the exception of bluebunch wheatgrass (*Agropyron spicatum*), needlegrass (*Stipa* spp.), and junegrass. Since there is a strong possibility of misidentification of grass species, it is believed that only the total for perennial grasses indicates the true picture. These totals show an overall loss of 14 percent resulting from fires and other causes.

Of the 105 line intercept plots checked, 15 had burned in the interim period. Of the bitterbrush segment loss, 53 percent occurred on burned plots, while 32 percent of sagebrush loss occurred on burned plots.

The figures indicate a downward trend in range conditions. The increase in annual vegetation is an indicator of range depletion. Cheat grass and other undesirable annual weeds soon take over an abused range.

The Mears and Plum Ridge fires had a marked effect on this downward trend. Percentage utilization by livestock and deer for the past two years (1951 and 1952) was at a level which should result in maintenance of the better forage plants. During the two previous years (1949 and 1950) over-utilization of the range occurred.

TABLE 15

Number of Line Transect Plots on Which Each Class of Ground Cover Occurs

Common name	Scientific name	1948	1952
Bare soil		101	101
Rock		71	79
Litter		105	105
Moss		12	11
Dead manzanita	*Arctostaphylos patula*	15	1
Dead sagebrush	*Artemisia* spp.	46	37
Dead rabbitbrush	*Chrysothamnus* spp.	18	21
Dead mahogany	*Cercocarpus ledifolius*	----	3
Dead phlox	*Phlox* spp.	----	1
Dead pine	*Pinus ponderosa*	----	1
Dead cherry	*Prunus* spp.	----	1
Dead bitterbrush	*Purshia tridentata*	55	48
Annual grasses		81	90
Annual weeds		83	86
Service berry	*Amelanchier alnifolia*	1	1
Manzanita	*Arctostaphylos patula*	2	4
Sagebrush	*Artemisia* spp.	60	50
Squaw carpet	*Ceanothus prostratus*	21	26
Mahogany	*Cercocarpus ledifolius*	1	1
Rabbitbrush	*Chrysothamnus* spp.	39	39
Juniper	*Juniperus occidentalis*	19	21
Incense cedar	*Libocedrus decurrens*	1	1
Yellow pine	*Pinus ponderosa*	13	8
Wild cherry	*Prunus* spp.	4	6
Bitterbrush	*Purshia tridentata*	73	57
Gooseberry	*Ribes* spp.	1	----
Horse brush	*Tetradymia* spp.	----	3
Yarrow	*Achillea* spp.	21	3
Antennaria	*Antennaria* spp.	6	7
Balsamroot	*Balsamorhiza* spp.	21	11
Wild buckwheat	*Eriogonum* spp.	9	3
Lupine	*Lupinus* spp.	2	1
Pentstemon	*Pentstemon* spp.	2	2
Phlox	*Phlox* spp.	7	1
Groundsel	*Senecio* spp.	4	----
Mule-ear	*Wyethia mollis*	21	13
Unclassified		7	9
Bluebunch wheatgrass	*Agropyron spicatum*	20	23
California brome	*Bromus carinatus*	2	7
Sedge	*Carex* spp.	53	44
Wild-rye	*Elymus* spp.	5	6
Idaho fescue	*Festuca idahoensis*	36	26
Junegrass	*Koeleria cristata*	16	11
Bluegrass	*Poa* spp.	86	57
Squirreltail	*Sitanion hystrix*	78	72
Needlegrass	*Stipa* spp.	84	80
Unclassified		1	3

Comparison of Line Intercept Plot and Line Point Plot Method

At the time the line intercept plots were remeasured, 90 were changed to the line point method on the same 200-foot line. The class of cover present over or under every other foot mark along the tape was recorded. This gave a total of 100 line points for each plot.

The line point plots were made 200 feet long, instead of the standard 100 feet now used on most deer ranges in California, in order to include juniper trees that had been tagged in the original line intercept

TABLE 16

Number of Segments That Contained Plants

Species	1948 No. segments	1952 No. segments	Percent loss in no. segments
Bitterbrush	262	183	30.4
Sagebrush	218	180	17.4
Rabbitbrush	71	66	7.0

TABLE 17

Ground Cover Composition in Points and Percentage, September, 1952

(Including Number of Plots on Which Each Class of Cover Occurs Based on 90 Plots, 200′ Long With Every Other Footmark Recorded)

Class of cover	No. points	Percent of cover	No. plots W/cover
Bare ground	1,668	18.9	90
Rock	539	6.0	68
Litter	3,088	33.9	90
Moss	18	.2	5
Dead sagebrush	183	2.1	48
Dead rabbitbrush	27	.3	17
Dead bitterbrush	192	2.2	55
Dead others	3	----	3
Total nonproductive	5,718	63.6	----
Sagebrush	409	4.5	54
Squaw carpet	211	2.3	26
Rabbitbrush	163	1.8	43
Juniper	149	1.6	36
Yellow pine	53	.6	20
Wild cherry	10	.1	4
Bitterbrush	484	5.4	65
Others	18	.2	7
Total browse species	1,497	16.5	----
Mule-ear	16	.2	5
Others	80	.9	26
Total per forbs	96	1.1	----
Annual grass	810	9.1	66
Annual forbs	291	3.3	56
Total annuals	1,101	12.4	----
Bluebunch wheatgrass	22	.2	12
Sedge	85	.9	31
Idahoe fescue	55	.6	18
Junegrass	7	.1	5
Bluegrass	99	1.1	38
Squirreltail	102	1.1	41
Needlegrass	213	2.4	52
Others	5	----	5
Total per grasses	588	6.4	----
Grand total	9,000	100.0	----

survey, and so that as many as possible of bitterbrush plants included in the earlier surveys would be included in the new sample.

Three painted iron reinforcing rods were driven on each plot: at the zero, 100-foot, and 200-foot marks. After the first 100 feet were recorded, the tape was moved to the second 100 feet. A lead plumb-bob was suspended by a string at each foot mark. For bare ground, litter, rock, moss, annual grasses, and all forbs, the dominant class of ground cover in a four-inch circle surrounding the point of plumb, was recorded. For perennial grasses the plumb point had to touch the basal area of the plant before a hit was recorded. For browses, the plumb point had to fall within the average perimeter of the crown to be recorded. Dead shrubs which were still in place were so recorded; if out of place, they were classified as litter.

Table 17 gives a breakdown of data taken by the line point method. Table 18 shows composition of the vegetation.

TABLE 18

Comparative Summary, Line Point and Line Intercept Methods

	Line point (Percentage)	Line intercept (Percentage)
Nonproductive	63.6	66.4
Annual vegetation	12.4	11.1
Shrubs	16.5	12.8
Perennial forbs	1.1	.9
Perennial grasses	6.4	8.8
Totals	100.0	100.0

On the 90 line point plots, none was placed on recently burned over land. It will be necessary to install line point plots on burned over range, if a representative sample of the management area is desired.

In order to compare the data from the line intercept and line point methods, a summary of the ground cover for the same plots is given in Table 18. In Table 19, a further breakdown is shown.

It is apparent there is a difference in the two methods of measuring ground composition. The line intercept method indicates a greater shrub coverage and less perennial grass. The line point method recorded less bare soil and litter. (See Table 20.)

Because of the strict standards of the line point method, on which the basal area of perennial grasses must be touched by the plumb-bob before a hit is recorded, as compared to that of the line intercept method, in which grass leafage, so long as it is hung over the line intercepts, is recorded, the decrease in perennial grasses can be explained readily.

The increased coverage of other classes of vegetation cannot be accounted for so easily. On the whole, the line point method, as used in

TABLE 19

Analysis of Vegetative Composition by Percentage, September, 1952
(Based on 90-line point plots—3,282 points of vegetation)

Plant species	Percent vegetation
Sagebrush	12.5
Squaw carpet	6.4
Rabbitbrush	5.0
Juniper	4.5
Yellow pine	1.6
Wild cherry	.3
Bitterbrush	14.7
Others	.5
Total browse species	45.5
Annual grass	24.7
Annual forbs	9.0
Total annuals	33.7
Mule-ear	.5
Others	2.4
Total perennial forbs	2.9
Bluebunch wheatgrass	.7
Sedge	2.6
Idaho fescue	1.7
Junegrass	.2
Bluegrass	3.0
Squirreltail	3.1
Needlegrass	6.5
Others	.1
Total perennial grasses	17.9
Grand total	100.0

the survey, employed stricter standards than those used in the line intercept method.

Either method is suitable for measuring trend in vegetative types, but the line point method has been adopted because it is less time consuming.

Form and Age Classes of Shrubs

In the course of the survey, shrubs were classified as to form and age class. Table 21 summarizes these data for bitterbrush, juniper, sagebrush, and rabbitbrush.

The absence of seedlings on the range is a matter of concern. While the line point method provides only indices of numbers of plants on a range, in that the probabilities lean toward the missing of smaller plants, field examinations support the plot data. Seedlings of bitterbrush have been found the past two years in the timber type, but close scrutiny of the sage and juniper types shows a complete absence of any small bitterbrush plants.

TABLE 20

Comparative Analysis of 90 Plots Measured With Line Point and Line Transect Methods, 1952

Ground cover	Line point	Line transect
Bare soil	18.9	20.5
Rock	6.0	5.0
Litter	33.9	36.6
Dead sagebrush	2.1	1.8
Dead rabbitbrush	0.3	0.3
Dead bitterbrush	2.2	2.0
Moss	0.2	0.2
Total nonproductive	63.6	66.4
Annual grasses	9.4	8.3
Annual weeds	3.3	1.8
Total annuals	12.4	11.1
Sagebrush	4.5	2.9
Squaw carpet	2.3	2.3
Rabbitbrush	1.8	1.2
Juniper	1.6	1.3
Yellow pine	.6	.4
Wild cherry	.1	.2
Bitterbrush	5.4	4.3
Others	.2	.2
Total shrubs	16.5	12.8
Balsam root	----	.4
Mule-ear	.2	.3
Others	.9	.2
Total forbs	1.1	.9
Bluebunch wheatgrass	.2	.4
Sedge	.9	1.6
Idaho fescue	.6	.6
Junegrass	----	.1
Bluegrass	1.1	1.2
Squirreltail	1.1	1.9
Needlegrass	2.4	2.9
Others	.4	.1
Total perennial grasses	6.4	8.8
Grand total	100.0	100.0

The age classification indicates that a high percentage of shrubs are in the decadent class, with very few young plants established to replace those which are passing out of the picture.

Forage Utilization

Each fall and spring, forage utilization checks have been taken on the range sample plots. In the fall period, after livestock have left the range and before deer have appeared, the key shrub species are measured for percentage of livestock utilization. At the same time, the average leader growth on bitterbrush plants is recorded. The following spring, when deer have left the range and before the livestock return, utilization is again checked on the same plants. The spring utilization check indicates the total use of the plants by both livestock and deer.

TABLE 21

Form and Age Class Index in Percentage, September, 1952
(Taken from 90-line point plots)

Species	Form classes*							
	1	2	3	4	5	6	7	8
Sagebrush	59.4	32.7	7.6	0.0	0.0	0.0	0.3	0.0
Rabbitbrush	84.8	12.0	3.2	0.0	0.0	0.0	0.0	0.0
Juniper	35.6	17.6	6.4	9.5	11.2	6.9	6.4	6.4
Bitterbrush	15.3	57.9	26.3	0.0	0.5	0.0	0.0	0.0

	Age classes			
	Seedling	Young	Mature	Decadent
Sagebrush	0.3	15.4	48.8	35.5
Rabbitbrush	0.0	21.6	53.6	24.8
Juniper	14.3	60.5	24.3	0.9
Bitterbrush	0.0	32.3	45.6	22.1

Number of plants checked

Sagebrush	330
Rabbitbrush	125
Juniper	391
Bitterbrush	406

NOTE: All junipers were classified that fell within 15 feet either side of the plot line.
* 1. All available, little or no hedging.
2. All available, moderately hedged.
3. All available, heavily hedged.
4. Partly available, little or no hedging.
5. Partly available, moderately hedged.
6. Partly available, heavily hedged.
7. Mostly unavailable.
8. Unavailable.†
† Includes only living plants.

The fall utilization figure is subtracted from the spring to derive that resulting from deer use alone.

The species checked for percentage of utilization are bitterbrush, juniper, sagebrush, and rabbitbrush. Any rodent use is noted separately, although it has been found to be insignificant in the over-all picture.

The fall measurement of the length of uncropped bitterbrush leaders also provides an index of the volume of growth produced during the current year. Comparative data on leader growth are given in Table 22. It will be seen that 1952 was an excellent growth year for bitterbrush.

Utilization figures for the last four years on bitterbrush are shown in Table 23.

Allowable use of bitterbrush for deer and livestock has been set at 38 percent. Since utilization is not evenly distributed over the management area, the allowance of an average percentage utilization of 60 percent would result in severe over-browsing on large areas of deer

TABLE 22

Bitterbrush Growth Index

Year	Inches of growth
1949	3.5
1950	3.2
1951	3.7
1952	5.4

concentration. The committee has set up the 38 percent figure to take care of this factor. Livestock and deer are each allotted 50 percent of the allowable forage crop, or 19 percent of the current year's growth. For the past two years, total use has been under that which is considered allowable.

A statistical check of the 1953 spring data on bitterbrush cropping indicates the odds are 19 out of 20 that the true mean lies within 24.5 and 32.1.

Although the utilization data indicate a steadily decreasing percentage cropping of bitterbrush leader growth during the past four years, the actual volume of forage consumed appears to have remained more constant. This is indicated by use indices. These use indices are the product of average percentage cropping times average inches of leader growth. They express the actual inches of growth taken. The use indices for the past four years are shown in Table 24.

The data indicate that the decline in percentage utilization is due partly to an increase in volume of growth during 1951 and 1952, as well as to a decrease in the amount of forage consumed.

The intensity of use on bitterbrush is shown in Table 25, which gives the figures for the past three years.

TABLE 23

Average Percentage Cropping of Bitterbrush

Year	Livestock	Deer	Total use
1949-50	18.8	29.5	48.3
1950-51	10.3	29.9	40.2
1951-52	16.1	18.2	34.3
1952-53	7.1	15.6	22.7

TABLE 24

Use Indices for Four Winter Seasons

Year	Livestock	Deer	Total
1949-50	0.7	1.0	1.7
1950-51	0.3	1.0	1.3
1951-52	0.6	0.7	1.3
1952-53	0.4	0.8	1.2

TABLE 25

Bitterbrush Intensity of Use

Average percentage of use	Percentage of plots in each class		
	1951	1952	1953
0–14.9	15	22	41
15–29.9	14	26	30
30–44.9	22	22	14
45–59.9	29	13	10
60 plus	20	17	5
Totals	100	100	100

Numbered boxcar seals have been placed on junipers that are on or adjacent to forage plots. Four twigs, so located that they are available to deer, are tagged on each juniper. These twigs are measured each fall from the car seal to the tip of the twig. In the spring, the same twigs are remeasured and the average percentage of cropping is derived. No limit has been determined as to the amount of cropping a juniper can withstand and still maintain its growth. Aldous (1941), in his experiments on northern white cedar (*Thuja occidentalis*), found that browsed limbs would not regenerate leafage if more than 25 percent of the foliage was removed annually. Table 26 gives the data on juniper cropping for the past six years. As shown in the table, cropping was very light in the winter of 1952-53.

Juniper measurements in the timbered areas should be discontinued, because deer appear to use very little juniper until forced out of timbered areas by snows to juniper types at lower elevations. Here the use of juniper during heavy winters is usually heavy. Because the measurements taken in timber types tend to outweigh those taken in the juniper-sage type, the present figures do not present the true picture of the importance of juniper in the midwinter diet of deer.

Over-all utilization of sagebrush and rabbitbrush has been slight in every year since the study started. However, it is measured each year to give data for comparison. Cropping of these species for the past year by livestock, deer, and rodents is given in Table 27. Table 28 indicates the total average use of these species during the four years 1949-50 through 1952-53.

TABLE 26

Juniper Utilization

Year	Percentage of twig growth taken
1947-48	14.0
1948-49	22.2
1949-50	12.3
1950-51	5.4
1951-52	10.4
1952-53	2.7

TABLE 27

Sagebrush, Rabbitbrush Utilization, 1952-1953

	Average percentage of cropping			
	Livestock	Deer	Rodents	Total use
Sagebrush	0.0	4.5	0.0	4.5
Rabbitbrush	0.8	2.9	0.3	4.0

Chemical Analysis of Some Browse Species

Each month, from October, 1950, through April, 1951, browse samples were collected in two areas on the winter range and sent to the Food Habits Laboratory in Berkeley. Bitterbrush, juniper, and rabbitbrush were collected from the Potter Pasture and Timber Mountain areas. The two areas were selected because of different types of soil and growth characteristics. The samples were analyzed for protein and ash content. Table 29 shows the results of the analysis.

Two other areas in the Great Basin Region that were also sampled were the Doyle in Lassen County and Elderberry and Buttermilk in Inyo County. Bitterbrush in Inyo analyzed higher than in either Lassen or Modoc. Sagebrush in Modoc ranged lower than in Inyo and Lassen Counties.

This information is only a part of the nutritional studies being carried on by H. D. Bissell of the Department's Food Habits Laboratory. As Bissell points out, "obviously, many things in addition to crude protein are significant in ruminant digestion."

SALTING STUDY

Although most areas of bitterbrush on the management area show signs of heavy use and declining condition, there are excellent stands of bitterbrush in the adjoining Glass Mountain winter deer range. During the falls of 1951 and 1952, a salting experiment was carried on to determine if it was possible to induce Devils Garden deer to follow salt trails into areas of abundant and lightly used browse on the Glass Mountain winter range. Blocks of salt were placed at frequent intervals along routes leading to the new range. Although this salting procedure

TABLE 28

Sagebrush and Rabbitbrush Utilization for Four Years (Percentage)

Year	Sagebrush	Rabbitbrush
1949-50	8.7	13.5
1950-51	9.4	11.7
1951-52	9.0	14.4
1952-53	4.5	4.0

TABLE 29

Chemical Analysis of Browse Species

	Content in percentage						
	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April
Bitterbrush							
Protein							
Potter Pasture	8.8	9.2	8.1	7.3	6.5	4.5	7.3
Timber Mt.	8.6	9.3	8.0	7.3	6.0	6.2	9.6
Ash							
Potter Pasture	----	2.1	2.2	----	----	----	----
Timber Mt.	----	2.2	2.2	2.0	----	----	----
Sagebrush							
Protein							
Potter Pasture	11.1	10.0	8.4	9.1	7.7	6.2	9.2
Timber Mt.	10.9	12.0	6.9	9.5	8.3	8.5	9.6
Ash							
Potter Pasture	----	2.9	2.5	2.4	----	----	----
Timber Mt.	----	3.0	2.2	2.1	----	----	----
Juniper							
Protein	7.8	7.8	8.6	5.6	5.6	6.9	6.7
Ash	----	2.8	2.9	----	----	----	----

was followed for two years, results were negative. Not only was there little use of the salt blocks during migration, but so far as is known, there was no success in changing the habitual movements and ranges of the deer.

BROWSE RESTORATION STUDY

Browse is a major item in the diet of deer and is especially important on snow covered winter ranges. Desirable browse has been greatly reduced by heavy grazing, fire, insect depredation, and other factors.

The California Forest and Range Experiment Station is undertaking a state-wide browse research project for the California Department of Fish and Game, using Federal Aid to Wildlife Restoration (Pittman-Robertson) funds. It is hoped findings will lead to practical methods of artificial reseeding and other cultural methods of restoring browse on depleted deer winter ranges.

A major portion of the study will be confined to the Devils Garden winter deer range. Plot sites have been selected and experiments are already under way. Deer-proof exclosures have been constructed at Doyle, Lassen County, and near Flukey Springs, Modoc County. The latter will inclose approximately five acres.

A variety of seeds has been collected and planted under different methods. Weather and soil conditions are being recorded. Means of soil preparation are being investigated. Phenological records of key species are being kept on experimental sites. Competition of low quality

plants with the more desirable species is also undergoing study. It will be necessary to extend this study over a period of years in order to secure all of the needed information.

In addition to the investigation being carried on by the Pittman-Robertson study, the Department's Habitat Improvement Crew is carrying on seed collection and plantings in the critical area. Eight plots, containing approximately two and one-half acres, were planted in 1952 with bitterbrush, mahogany, and sagebrush seed. Due to the lack of proper seeding equipment, and other factors, the plantings have not shown encouraging results.

The crew has also constructed a 100-foot square deer exclosure with a 100-foot square stock exclosure adjacent, near Flukey Springs. It was completed in July, 1953, and over a period of years will show the effect on browse species of complete grazing protection and the effect of protection from livestock alone.

Range Grass Reseeding

Over a period of years, the Forest Service has carried on a range reseeding program to which the Department of Fish and Game has contributed. Burned over range has received the bulk of the seed. The seeding was generally a mixture of crested wheat (*Agropyron cristatum*), smooth brome (*Bromus inermis*), and timothy (*Phleum pratense*). Various other species of grasses and legumes have been tried on smaller scales. Best results have occurred with the above named species.

In the Mears Burn, 6,785 acres were reseeded. The work was done by the Modoc National Forest, with the Department of Fish and Game contributing 10,000 pounds of seed to the project. The timbered area was planted by airplane. Smooth brome has shown up in a vigorous stand in the southeast corner of Potter Pasture from this seeding.

Table 30 shows data on area seeded in the Devils Garden area.

TABLE 30

Range Reseeding Data on Devils Garden Winter Range

Year	Area	Acres	Type of seeding
1945	Dry Lake	12	Drilled
1945	Hartlerode (Doublehead)	24	Drilled
1946	Tucker Lake	15	Drilled
1946	Clear Lake Hills	20	Drilled
1946	Mud Lake	35	Drilled
1946	Saddleblanket Flat	179	Drilled
1947	Saddleblanket Flat	265	Dixie Drag
1947	Clear Lake Hills	540	Drilled
1948	Clear Lake Hills	366	Drilled
1949	Holbrook Flat	200	Drilled
1950	Plum Ridge Fire	3,500	Broadcast in ashes
1951	Mears Fire	6,000	Broadcast in ashes
1951	Mears Fire	765	Drilled and Dixie Drag
1952	Mears Fire	20	Drilled
1952	Mowitz Fire	20	Drilled
	Total acreage	11,991	

LIVESTOCK ON THE RANGE

During the past five years, 1948 to 1952 inclusive, livestock use has been reduced on the Devils Garden management area. Sheep use has been reduced by the changing and shifting of allotments. Nonuse by cattle in the Potter Pasture has lessened the pressure in the burned area that has been reseeded. Dual use is being eliminated.

Table 31 gives the livestock obligations for livestock allotments which fall within the key area. These figures differ from those given in the Fifth Progress Report of the Devils Garden Interstate Deer Herd Committee, which shows the obligations for most of the winter range.

The obligations for the management area for 1948 as compared with 1952 show: 1948—12,335 animal unit months, and 1952—9,115 animal unit months. This represents a 26 percent reduction in livestock grazing obligations over the four-year period.

DEER HARVEST

The buck kill for the California summer and winter range was determined from returned deer tags and is shown in Table 32. The kill for the Oregon portion of the Interstate range is given in Table 33.

In 1951, the legalization of forked horn deer in District $1\frac{3}{4}$ coupled with early storms brought about the largest harvest of bucks ever experienced in Modoc County. In 1952, very few of the Interstate deer got down onto the winter range until after the hunting season was over. This resulted in a very low kill.

TABLE 31

Livestock Obligations on Key Area of Devils Garden Winter Deer Range for 1948 and 1952

Allotment	Head	Animal unit months
1948		
Clear Lake Spring	530 Cattle	930
Clear Lake Spring	13,400 Sheep	4,985
Dry Lake	346 Cattle	1,580
Mowitz	300 Cattle	1,500
Potter Pasture	470 Cattle	1,880
North Badger	925 Sheep	740
South Badger	900 Sheep	720
Grand total	16,871	12,335
1952*		
Clear Lake Spring	8,000 Sheep	2,503
Mowitz	900 Sheep	720
Casuse	1,250 Sheep	375
Brown's Well	1,000 Sheep	333
Dry Lake	431 Cattle	2,086
Tucker	750 Cattle	2,046
Potter Pasture	263 Cattle	1,052
Grand total	12,594	9,115

* Cattle remaining on the Clear Lake Spring allotment as of 1948 have been moved on to a portion of it, outside the key area.
The Brown's Well allotment is the former North Badger with a minor boundary change.
South Badger is no longer considered a part of the key area.
Casuse has been added. There is little change in the gross area.

TABLE 32

Deer Kill on the California Portions of the Deer Range

Year	Antlerless	Bucks	Totals	Remarks
1937		404		
1938		497		
1939		561		
1940		825		
1941		402		
1942		236		War year
1943		207		War year
1944		244		War year
1945				War year
1946		541		
1947		615		
1948				
1949		670		Storms late in hunting season.
1950	1,319	410	1,729	Dry season, late migration.
1951	1,504	967	2,471	Forked horns legal, storms.
1952		153		Dry season, no migration. Forked horns legal.

The 1951 Devils Garden special antlerless deer season went off with less opposition than the 1950 hunt (for a description of the 1950 hunt, see Interstate Deer Herd Committee, 1951). The recommendation of the Interstate Committee at the public hearing was to harvest 4,000 antlerless animals, 2,000 to be taken in Oregon and 2,000 to be taken in California. This was accepted. Later, after the Mears fire, the committee asked that an additional 4,000 animals be taken. No action was taken on this request.

In California, over 26,000 applications were received for the special hunt and 2,300 names were drawn. Of these, 1,818 accepted permits and 1,716 hunted. Of these hunters, 1,504 or 88 percent were successful.

The Oregon Game Commission states that 2,343 antlerless deer were taken during their 1951 season. This made a total of 3,847 deer taken out of the 4,000 proposed.

Analysis of the Kill Figures

Of the total animals checked, the age classes indicated mature does 75.5 percent; yearlings 12.5 percent (16 percent males); fawns 12 percent (56 percent males). In the 1950 antlerless take, yearlings formed 13.6 percent of the total and fawns 17.5 percent.

TABLE 33

Deer Kill on the Oregon Portion of the Interstate Range *

Year	Antlerless	Bucks	Totals	Remarks
1949		2,500	2,500	
1950	688	1,500	2,188	
1951	2,343	2,422	4,765	
1952			2,400	Includes antlerless deer taken in a four-day either sex season at end of regular buck season.

* The figures for bucks are estimates; the figures for antlerless deer are exact.

The percentage of yearling does taken in antlerless hunts can be used as an indication of yearling survival. This assumes that in an antlerless hunt, hunters are indiscriminate in the taking of yearlings or mature does. In the 1951 antlerless hunt, 14 yearling does were taken to every 100 mature does. During the previous fall (1950), a fawn: doe (yearling and mature) ratio of 77 to 100 was obtained in classification counts.

It was found in the 1950 antlerless bag that 20 percent of the does were yearlings. From this it can be computed that there were 96 fawns per 100 mature does in the fall of 1950. Assuming that 50 percent of the fawns were females, there were 48 female fawns per 100 does at that time. In a year's time, the ratio dropped to 14 per 100 mature does, a fawn loss of 71 percent, which occurred during the relatively mild winter of 1950-51.

These figures are noteworthy in that they show large losses occurring even in years of mild winters and are a further indication of the effects of crowded conditions on this winter range.

GUIDES TO MANAGEMENT

The first objective in the management of the Devils Garden winter deer range is to determine the productive capacity for grazing and browsing animals of these public lands, which have been depleted by past abuse. The range is used by sheep in the spring and summer, cattle during the spring, summer, and fall, and by a migratory deer herd during the winter season.

The second objective is to balance the combined range use by livestock and deer so that no more than the average forage crop produced on the range is consumed each year.

With the experience over the years, the management methods and techniques developed have resulted in the following changes in the management plan drawn up in 1948:

1. Originally, utilization measurements were made on plants occupying the 25-inch intercepts on the 200-foot line plots. Later, it was decided that a larger number of plants would tend to give a better sample of range use. To get this larger sample, browse plants that fell on line between the intercepts or close to them were included in the utilization check. An attempt was made to get at least four plants on each plot. The addition of the plants not on intercepts made a change in computation methods necessary. All plants were given equal weight and straight arithmetical averages of percentage cropping were adopted.

2. The allowable use of bitterbrush had been set at 34 percent under the original computation method. While Hormay's (1943) work on bitterbrush indicated that an allowable use of 60 percent was the maximum amount of cropping of the current year's growth that an individual plant could sustain and still remain vigorous and reproduce satisfactorily, it was recognized that an average of 60 percent for the entire range would result in extreme use in some areas, balanced by light use in others. In order to protect the range on which deer use was heaviest, the average of 34 percent was adopted. When the sample was enlarged and the weighing feature of the computation was discontinued, the committee raised the allowable use factor to 38 percent.

3. The type of plots used for ground cover composition and forage utilization was changed in 1952 from line intercept to line point.

4. The coverage by forage plots has been reduced from the total winter range to the key management area.

5. Measurements of utilization were once made on perennial grasses, but due to the over-all light average use of grasses by deer and the time consumed in determining this utilization, the check was discontinued. Utilization checks are now restricted to bitterbrush, sagebrush, rabbitbrush, and juniper, the most important browses on the winter range.

6. Pellet counts are made only on the management area, and are now used to show trends in relative use rather than as a deer census method.

7. The car strip census to determine deer numbers was discontinued because the weather conditions were too often such as to result in poor counts. Also, the roads were sometimes impossible to travel, which prevented gathering of comparative data each year. Herd composition has been continued as before, but it is not limited to the car strips.

8. Since weather conditions have a great deal to do with the amounts of forage produced each year, it was thought that a three-year running average of utilization would be the best base from which to determine allowable deer and livestock numbers. This did not take into consideration the effect of severe winter mortality on deer numbers, as experienced during the winter of 1951-52. Once that weakness was revealed, the Interstate Committee began to use straight year by year averages to determine allowable numbers. The utilization by deer, measured in the spring of 1952, seemed to approach the desired level. It is hoped by the committee that the breeding herd can be held at that level until the range conditions are improved, at which time a new deer population ceiling could be set. The 1952 spring population of interstate deer numbered approximately 12,000 animals.

SUMMARY

The Interstate Deer Herd Committee was organized in 1945 to study the Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) problem on the Devils Garden winter range. This is the eighth progress report of the findings of this committee.

Numerous fires have burned over the winter range since 1936, depleting approximately 65,000 acres of the key wintering area.

The state line track count has proved to be the most reliable method for obtaining deer numbers. The actual tally during 1953 was 11,601 animals. It was estimated that an additional 3,000 animals were missed, due to unfavorable weather and counting conditions.

The pellet count is now used as an indicator of relative use on the key management area. During the winter of 1952-53, the use was light, reflecting a scattered deer herd in a mild winter.

The 1951-52 winter was severe with heavy snows. These snows forced the deer to concentrate on areas where little food was present, resulting in a winter loss calculated to be approximately 32 percent of the total herd.

Deer collected from highway kills, railroad kills, and caught in fences have been an excellent source of information for food habits, productivity, condition, and numerous other data.

Herd composition counts each year have shown a consistency in a low percentage of bucks. However, the good fawn production indicates that there is still an adequate number of breeding males. The increasing number of spike bucks may be the result of a decline in good deer forages.

The results of the survey of ground cover composition made after a four-year period indicate a downward trend in range conditions, which can be attributed primarily to fire. There was a small decrease in nonproductive ground cover, a large increase in annual grasses and weeds (mostly undesirable), a decrease in the most important browse species, and decreases in perennial weeds and grasses.

Annual forage utilization checks indicate that during 1951-52 and 1952-53 the deer population was close to the proper number for range maintenance. During previous years of study, overstocking, mainly by deer, tended to cause further range depletion.

REFERENCES

Aldous, Shaler E.
1941. Deer management suggestions for northern white cedar types. Jour. Wildl. Mangt., vol. 5, no. 1, p. 90-94.

Cheatum, E. L.
1949. Bone marrow as an index of malnutrition in deer. N. Y. St. Conservationist, vol. 3, no. 5, p. 19-22.

Hormay, August L.
1943. Bitterbrush in California. Calif. Forest and Range Expt. Sta., Research Note no. 34, 13 p. (Multilith)

Interstate Deer Herd Committee
1951. The Devils Garden deer herd. Fifth progress report of the interstate deer herd and its range, including a summation of work to date. Calif. Fish and Game, vol. 37, no. 3, p. 233-272.

Rasmussen, D. I., and E. R. Doman
1943. Census methods and their application in the management of mule deer. Eighth No. Amer. Wildl. Conf., Trans., p. 369-380.

NOTES ON THE HABITAT OF THE DESERT BIGHORN IN THE SAN GABRIEL MOUNTAINS OF CALIFORNIA[1]

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INTRODUCTION

The desert bighorn (*Ovis canadensis nelsoni*) ranges in portions of the desert areas of California and adjacent Nevada and Arizona. It is found as far north as the White Mountains in Mono County and south to the Mexican border. In Southern California its habitat is mostly in the rugged terrain of the Upper and Lower Sonoran Life Zones, below 4,000 feet elevation. To the west, however, in the San Gabriel and San Bernardino mountains, where higher life zones occur, bighorns are found in the conifer forests of the Transition Life Zone and above.

Ober (1931) of the California Division (now Department) of Fish and Game discussed the race and gave much life history data on the Inyo and Mono County herds. The species in Death Valley National Monument was studied by Dixon and Sumner (1939).

During the past 10 years, the authors have had many opportunities to observe desert bighorns in the San Gabriel Mountains. The habitat here and its use by these sheep differs greatly from the remainder of the area occupied by the species. Most of these notes are from observations by the senior author in the vicinity of the head of the South Fork of Lytle Creek, and the lower slopes of the middle fork of this stream, all within the San Bernardino National Forest. The junior author has observed a number of mountain sheep herds in the State, and has given particular attention to these animals in the San Antonio drainage in the Angeles National Forest.

HABITAT

The San Gabriel Mountains lie in Los Angeles and San Bernardino Counties, California, extending from the Santa Clara River on the west to Cajon Pass, some 60 airline miles to the east. They rise abruptly from the coastal valleys, reaching an elevation of 10,000 feet on Mt. Baldy. The crest of the range is above the 5,000-foot contour for most of its length.

The sheep summer in the conifer belt, mostly above the 6,500-foot contour. During winter and early spring, one herd may be found as low as 2,500 feet on a series of low ridges between the South Fork and Middle Fork of Lytle Creek. There is only meager information on the wintering area of the San Antonio herds, and this indicates they seldom go below the 3,500-foot level in winter. Summer and winter ranges

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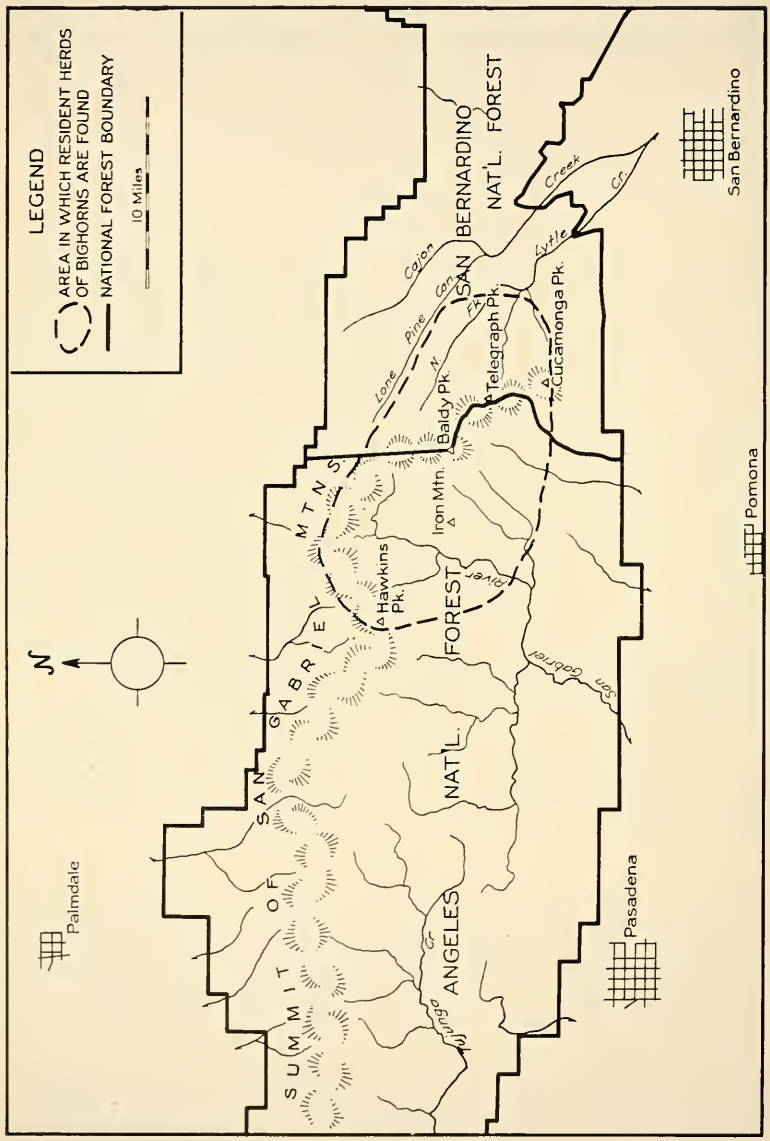

FIGURE 1. Map showing the area of the San Gabriel Mountains where sheep are known to occur.

are usually contiguous, so that the sheep are not forced to make extensive mass migrations.

The territory of individual herds appears to encompass a small area; however, individuals may stray widely. These wanderers are assumed to be young or quite old males that have lost in the battle for herd leadership. These individuals are known to leave their parent herds and stray great distances, perhaps in search of other opportunities.

Figure 1 shows the area in which there are definite herd territories and sight records which include the casual ramblings of individual sheep.

Water appears to be essential for their livelihood, at least in the summer. The sheep appear to water early in the day. Watering places are far apart and usually in deep gulches or canyons rarely frequented by the public.

Domestic livestock are not present on their range.

The combination of food and cover requirements results in their habitat being fairly well delineated by geology. Their search for roots and foliage of certain herbaceous plants takes them to areas of deep soil. Their escape "cover" consists of the typically rugged, cliffy areas for which the genus is noted.

Geologically, the San Gabriel Mountains are a rather young uplift. The deeper soils are on the ridges, usually at the higher elevations. The canyons are deeply cut, and mostly steeper than the normal angle of repose for fertile soil. The mountain sheep habitat, therefore, consists of these high ridges with deeper soils, the floristic belt where desirable forage species occur, and where there is adjoining rugged terrain.

FOOD HABITS

The food supply for bighorns in the San Gabriels is not abundant, and as a result, the herds can never be large. A variety of shrubby and herbaceous plants is taken. The forage supply of one herd may be almost entirely different from that of another, depending upon availability of the forage. With the exception of silvery lupine, no individual forage species was found commonly throughout the summer ranges.

Table 1 lists the important forage species grouped by shrubs and forbs, and then under these categories in order of their value based on observed use and abundance.

Black oak (*Quercus kelloggii*), coastal sagebrush (*Artemisia californica*), bitter cherry (*Prunus emarginata*), mormon tea (*Ephedra* sp.), rabbitbrush (*Chrysothamnus* spp.), and Brewer oak (*Quercus garryana* var. *breweri*) are not common in the habitat, but are quite closely used where they occur. Manzanitas (*Arctostaphylos* spp.) and live oaks are common but only occasionally nibbled. Chinquapin (*Castinopsis*) is common but rarely eaten. Some winter fat (*Eurotia lanata*) and mock locust (*Amorpha californica*) are taken.

Common forbs only occasionally cropped are pentstemon and monkey flower (*Mimulus*).

Bunch grasses such as *Poa*, *Bromus*, *Stipa* and *Sitanion* all may show signs of cropping early in the year, before seed stalks appear. The dry leafage is lightly eaten in winter. Annual grasses are eagerly sought

TABLE 1

List of Desert Bighorn Forage Plants

Scientific name	Common name	Use and abundance
Browses		
Ceanothus cordulatus	Sierra whitethorn	Eagerly sought in the eastern end of the range. Not common elsewhere.
Ceanothus integerrimus	Deerbrush	Closely cropped and a most palatable browse. Used heavily during summer and fall. A valuable browse in some areas at lower elevations for fall-winter range.
Ribes spp.	Wild currant	Not common but eaten wherever found.
Eriogonum spp.	Wild buckwheat	Two species are common and important: *E. ovalifolium*, a cushionlike or matted plant, and *E. umbellatum*, more erect. The former is grazed the year around and, in some places, kept to a low mat; the latter less closely used. The value or palatability of the wild buckwheats is often questioned for both deer and domestic livestock, but there is no doubt of the value of these two species for mountain sheep. The abundance and wide distribution of this genus makes for a staple year-long feed where more succulent forage does not exist.
Salix spp.	Willow	The willow thickets in shallow draws showed evidence of light browsing.
Cercocarpus ledifolius	Mountain mahogany	Available parts closely eaten, but not always common, and often too tall to reach.
Abies concolor	White fir	Shows occasional nibbling.
Pinus ponderosa	Ponderosa pine	Parts of needles were taken near bed grounds. Terminal buds were untouched.
Yucca whipplei	Chaparral yucca	Tips of leaves stripped, leaving fibers hanging.
Forbs		
Lupinus spp.	Lupines	Silvery lupine *L. breweri* is widely distributed and is one of the best herbaceous foods. It grows on the deeper soils and is a good indicator of potential mountain sheep habitat. As with domestic livestock, lupines are eaten mostly from August into October. The tall lupines, while more succulent, do not receive the use of silvery lupine, and are taken mostly in the fall after pods have opened.
Trifolium spp.	Clover	Closely cropped wherever found.
Lotus spp.	Trefoil	The prostrate species are often sought.
Lotus scoparius	Deerweed	Does not grow above 5,000 foot elevation, but is an important plant.
Astralagus bicristatus and *A. inflexus*	Loco weed	Cropped most in late fall or when almost dry.
Agastache urticifolia	Giant hyssop	Good forage, especially in the fall.
Pedicularis semibarbata	Lousewort	Herbage grazed in spring.

out by bighorns feeding along the south face of low ridges in March and April. These supply the earliest green feed.

NUMBER OF SHEEP PRESENT

Ranger Taylor of the San Bernardino National Forest and the senior author have estimated the Lytle Creek herd at 60 head, with the possibility of there being as many as 100 head in the San Bernardino portion of the San Gabriel Mountains. Ranger Anselmo Lewis of the Mt. Baldy district of the Angeles National Forest estimates that the population in the San Antonio drainage and other parts of the San Gabriel Mountains on this forest at 60 head. It is believed by the writers that the present estimates are quite conservative.

There appears to be a good distribution of age classes in the herds sighted. Young animals, lambs, and yearlings predominate, leading to the supposition that the herds are thrifty and possibly increasing.

BREEDING AND LAMBING

The rutting season of the Lytle Creek herd begins in late September. Lambs are dropped mostly in April. Lambs observed the first week of June were able to traverse cliffs with an agility almost equal to that of their mothers. Two sets of what were assumed to be twins have been observed.

DISCUSSION

The desert bighorn, from its habitat in the San Gabriel Mountains, can look down on an area with a present population of nearly 3,000,000 persons. The threat of disturbance is very great, yet due to the ruggedness of the terrain and other factors of accessibility, such as fire closures and few roads, it appears that numbers may possibly increase.

Management should include a continuance of its protection from shooting and vigorous law enforcement. A policy of minimum development and judicious location of any trails in its territory should be followed, so as to keep disturbance by human beings to a minimum.

REFERENCES

Ober, E. H.
1931. The mountain sheep of California. Calif. Fish and Game, vol. 17, no. 1, p. 27-39.

Dixon, J. S., and E. L. Sumner, Jr.
1939. A survey of desert bighorn in Death Valley National Monument, summer 1938. Calif. Fish and Game, vol. 25, no. 2, p. 72-95.

NATIVE POSTLARVAL FISHES OF THE LOWER COLORADO RIVER BASIN, WITH A KEY TO THEIR IDENTIFICATION[1]

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Little is known about the early life history stages of the freshwater fishes of North America, particularly from the point of view of systematics. The information available for the identification of larval freshwater fishes is largely scattered throughout life-history studies except for three important contributions by Fish (1929a, 1929b, 1932). Papers on freshwater fishes from western North America that contain figures of larval stages include those by Fry (1936), Kopec (1949), Weisel and Newman (1951), and Douglas (1952. Figure 3 is *Rhinichthys osculus*, not *Xyrauchen texanus*). A helpful comparative study (with figures) of the young of the five species of Pacific salmon was published by Foerster and Pritchard (1935).

It is frequently important that biologists be able to identify correctly the eggs and young stages of fishes. This is often necessary for the solution of such problems as the location of breeding sites, the distribution and biology of the larvae, and the conservation of populations (Balinsky, 1948). The abundance of a year class may be determined by the environmental conditions that act on the critical larval periods. An understanding of the early sequences in its life history may bear significantly upon the origin and relationships of a species (Orton, 1953).

During an ichthyological survey of the lower Colorado River system in the spring of 1950, the authors collected numerous early stages of many of the native fishes (Figure 1). Gathering life-history data was one of the objectives of the survey. Specimens were obtained with fine-meshed dip nets and wire strainers, and some of the best larval collections were secured at night with the aid of a bright light. For the purposes of this paper, the lower Colorado River is defined as that part of the river and its tributaries that lie below Lake Mead (Hoover Dam). This includes all of the Gila River system, which is the major drainage basin of the southern half of Arizona and of western New Mexico. Nearly all of the early stages of 12 species are represented in the collections.

The species treated in this paper belong to two families, the Catostomidae (suckers) and Cyprinidae (minnows), which are among the most difficult of all freshwater fishes to identify. The following six species of minnows are keyed out, although postlarvae of *Ptychocheilus* were not obtained: *Agosia chrysogaster* Girard, *Gila robusta* Baird

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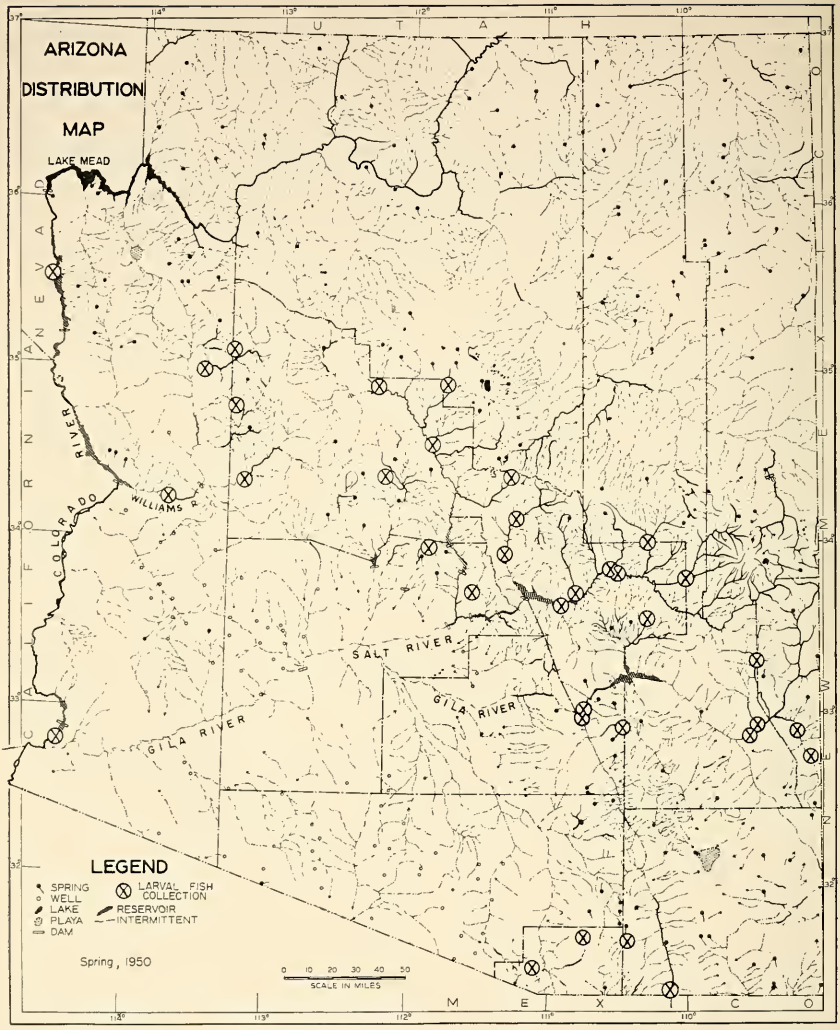

FIGURE 1. Drainage map of Arizona, showing stations where larval fishes were collected in 1950. In addition, there were three stations in Mexico and five in New Mexico.

and Girard, *Meda fulgida* Girard, *Ptychocheilus lucius* Girard, *Rhinichthys osculus*[2] (Girard), and *Tiaroga cobitis* Girard. *Plagopterus argentissimus* (Cope), formerly present in the Gila River, is now probably extinct in that drainage (no specimens have been reported since 1898). The following six species of suckers were studied: *Catostomus insignis* Baird and Girard, *Catostomus latipinnis* Baird and Girard, *Pantosteus clarki* (Baird and Girard), *Pantosteus delphinus* (Cope), *Pantosteus* species, and *Xyrauchen texanus* (Abbott).

[2] A proposed revision in the International Rules of Zoological Nomenclature (Bull. Zool. Nomen., vol. 4, 1950, p. 330) required the replacement of *osculus* by *nubilus*, for reasons of line priority. That ruling was revoked, however, at the Copenhagen Congress in 1953 (Copenhagen Decisions on Zoological Nomenclature. Ed. Francis Hemming. Int. Trust for Zool. Nomen., 1953:66.).

Five other families of native fishes are represented in the basin of the lower Colorado River: Elopidae (*Elops affinis*), Salmonidae (*Salmo gilae*), Cyprinodontidae (*Cyprinodon macularius*), Poeciliidae (*Poeciliopsis occidentalis*), Mugilidae (*Mugil cephalus*), and Eleotridae (*Eleotris picta*), which has only been recorded once (Hubbs, 1953). *Gillichthys detrusus* (Gobiidae) does not penetrate the Colorado River much beyond tidal influence.

We are grateful to Fred Anderegg, Supervisor of Photographic Services, for taking the photographs, and to William L. Brudon, Artist of the Museum of Zoology, for mounting these and retouching the backgrounds. William L. Cristanelli of the Michigan Institute for Fisheries Research, drafted the map (Figure 1).

METHODS AND TERMINOLOGY

The identification of the larval fishes was based upon critical laboratory studies of preserved material (fixed in 10 percent formalin). Since there was no opportunity to rear the larvae, the ages of the specimens are not known. Confidence in the accuracy of our identifications was assured by the limited fish fauna and by the following methods:

1. The many individuals of each species secured varied in size from juveniles to the smaller stages that lacked adult characteristics. Some intermediate specimens exhibited both adult and larval characters in various combinations. Thus, we could trace the sequence of developmental stages from the earliest (prolarvae, in some species) to those showing the distinctive features of the adult.
2. A number of collections contained only two species, a sucker and a minnow, and these species pairs varied sufficiently in different samples to include all representatives of both families. Thus, when numerous species of suckers and minnows were taken together, it was possible to verify identifications by comparison with the collections that contained only a single species of either group.
3. For one cyprinid, *Agosia chrysogaster*, the young with yolk sacs (prolarvae) were collected in the gravel nests of the adults.

Hubbs (1943) divided the early stages of fishes into the embryo, prolarva, postlarva, alevin, and juvenile. He pointed out that the word larva is used as a general term for all of the young stages of fishes. The term alevin is used for species in which the yolk sac larva (prolarva) transforms directly into the juvenile. It seems more logical to refer to such stages as juveniles, although the term alevin will probably be used, as in the past, by students of salmonid fishes.

The postlarval stage, with which we are concerned, was defined by Hubbs as the period after the absorption of the yolk and is only applied when the structure and form continue to be strikingly unlike that of the juvenile. This leaves doubt as to the end of the postlarval period and to the interpretation of "strikingly unlike." It may be questioned whether many freshwater fishes, in the period after the prolarva, would be considered strikingly unlike that of the juvenile. However, it seems advisable to use the term postlarva for the period after the prolarva

when (1) a continuous finfold is present, (2) there are pigment characters different from those of the juvenile, or (3) the fins are absent, unossified, or developed to various degrees. It would serve no useful purpose to add another term. We therefore redefine the postlarva as the period after the absorption of the yolk to a stage when the fish resembles the juvenile. The end of the postlarval condition in many marine fishes may be recognized by a striking transformation to the adult-like form or, in most freshwater fishes, by the loss of most of the finfolds and the ossification of the rays of the pelvic fins. The two latter criteria characterize satisfactorily the suckers and minnows and most egg laying North American freshwater fishes, as nearly as we can determine. An even more precise definition is that the postlarva corresponds to developmental stages 33 to 40 (Balinsky, 1948; p. 337-338, summarized below) in the Cyprinidae and Catostomidae. In this way an accurate definition of the larval stages is established. These stages probably do not deviate greatly in most other families of freshwater fishes. The Hiodontidae, Coregonidae, Esocidae, Catostomidae, Cyprinidae, Percopsidae, Centrarchidae, Percidae, Cottidae, and others have a postlarval period. This is absent in the Salmonidae and Ameiuridae. All groups have the earlier prolarva, which corresponds to stages 27 to 32 (see below).

The distinction of the postlarval stage serves two purposes. From the systematic standpoint, it characterizes a period when most, if not all, specific characters used for identification are at least superficially different from those of the adult. From a functional point of view, it is a unique period when the microhabitat, feeding, sensitivity to environmental fluctuations, and other behavioral differences are often quite different from those of the adult.

We have followed the terminology given by Balinsky (1948), with very few modifications and additions. He divided the chromatophores into four horizontal series:

1. The *dorsal pigment line*, which consists of pigment rows or scattered pigment along the dorsal edges of the myotomes and/or the dorsal integumentary pigment.
2. The *lateral pigment line*, which comprises the rows of pigment along the side. These are divisible into (a) pigment on the myomeres and (b) a single row of cells along the horizontal myoseptum. The lateral pigment line should not be confused with the lateral line (as was evidently done by Fish (1932)), a sense organ that does not coincide with the horizontal myoseptum.
3. The *ventro-visceral pigment line,* which is internal, lying along the intestine.
4. The *unpaired midventral line,* which may be internal, external, or both.

Additionally, we subdivide the dorsal head pigment into the occipital, the interorbital, the narial, and the upper lip pigment. Some of the differences between Balinsky's usage and ours are explained by his utilization of live, transparent material, whereas our specimens are preserved. The employment of internal characters with live material is generally impractical for routine identification.

Thirteen measurements taken on a series of the postlarvae of each species failed to show diagnostic differences within the Cyprinidae or

Catostomidae. Some features were found to separate the two families; the most reliable one was used in the key. (See also Table 1.)

For each species over 100 specimens were available, except that only 17 of *Tiaroga cobitis* were secured. Few juveniles of *Catostomus latipinnis* were obtained, but a large collection with all stages from the Green River, Wyoming (U. M. M. Z. No. 92248), was utilized. We did not collect postlarval stages of *Plychocheilus lucius*, a species now rare in the lower Colorado River system.

Developmental Stages

Balinsky (1948) gave a table of developmental stages for the Cyprinidae that was modified from Oppenheimer's (1937) table for *Fundulus heteroclitus* (Linnaeus). Such an arrangement of diagnostic stages makes it possible to compare corresponding stages of different species. Comparisons based on the alternative criteria of equal lengths and equal ages are usually unsatisfactory. However, it is useful to know the lengths of the specimens and also whether size differences exist between species at equal developmental stages. Balinsky did not give the length of his fish or state whether the species were of different sizes at similar stages of development. Variations in the time of appearance of some of the larval characters of the species studied by us are shown in Table 1.

It seems worthwhile to briefly summarize the cyprinid stages worked out by Balinsky. These define the limits of the postlarval period and call attention to a useful method for future studies of the larval stages of North American fishes.

Table of Normal Stages of Development of Cyprinid Fishes

(Condensed from Balinsky (1948))

Stage 1. Unfertilized egg.

Stages 2–27. Development of fertilized egg. Hatching occurs at about stage 27.

Stages 28–32. Prolarval stage with yolk sac.

Stage 33. Yolk is assimilated; no caudal fin rays present.

Stage 34. End of notochord straight; caudal fin with 3–4 rays; no trace of dorsal or anal fin.

Stage 35. End of notochord upturned; caudal fin with 7–9 rays; elevated fin membrane at site of future dorsal and anal fins.

Stage 36. Dorsal and anal with rudimentary, cartilaginous rays; caudal fin rounded, nearly complete, with 15–17 rays. Air bladder subdividing.

Stage 37. Rays of dorsal and anal fins partly ossified; caudal emarginate, with 19 principal rays; rudiments of pelvics appear. Air bladder subdivided into two parts.

Stage 38. Pelvic fins in the form of crescentic folds.

Stage 39. Pelvic fins in the form of paddles, with no trace of rays.

Stage 40. Pelvic fins with rudimentary, unossified rays.

Stage 41. Pelvic rays partly ossified. Continuous finfold reduced.

Stages 42–46. Finfold lost, scales develop, and lateral-line canal forms.

The embryo occupies stages 2 to 27, or to hatching if it occurs in some other stage. The prolarval or nonfeeding period is from stages 28 to 32 and the postlarval or feeding larva is from stages 33 through 40. The five cyprinids we studied follow the above stages rather closely, and these stages can also be used as a basis of comparison for the Catostomidae. The first loop of the intestine in the suckers forms in stage 37, whereas the mouth descends to a normal ventral position between stages 39 and 40. In stage 37 some of the dorsal rays ossify before the

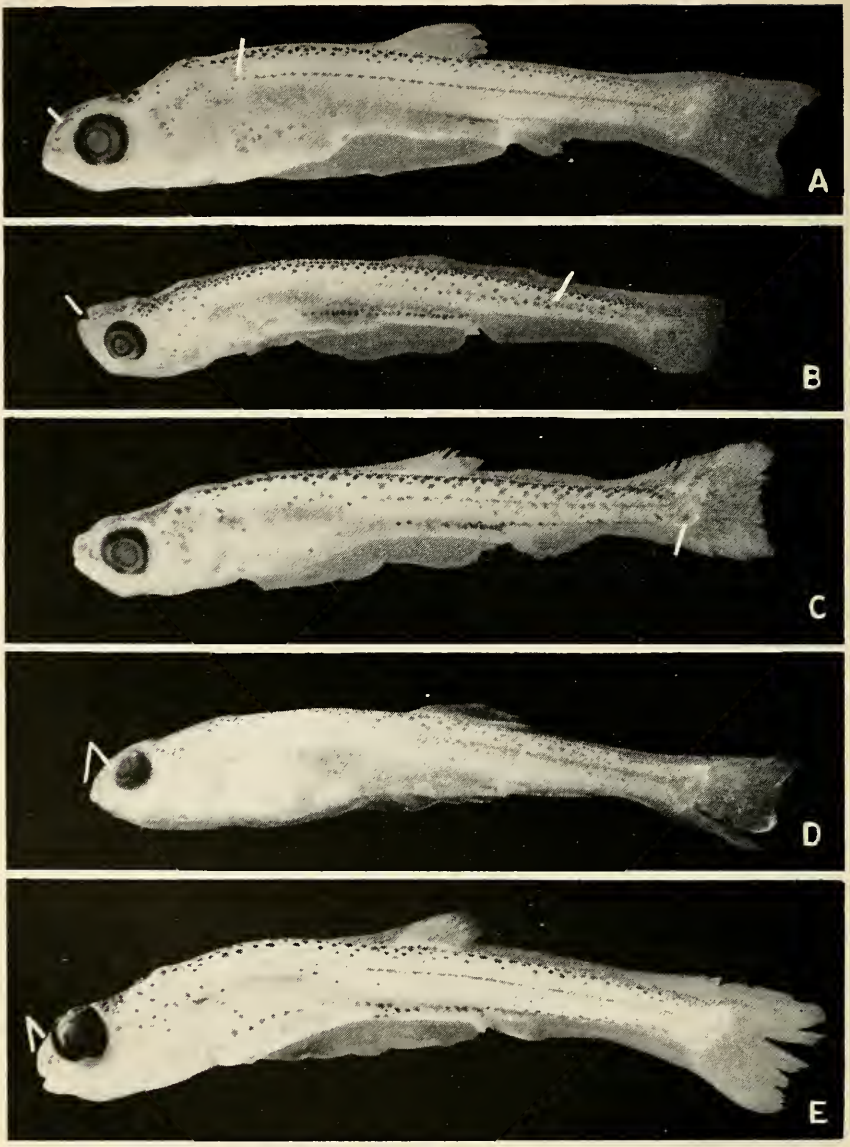

PLATE 1
Lateral Views of Postlarval Minnows

A, *Agosia chrysogaster*, total length 10.1 mm., UMMZ No. 162705; B, *Meda fulgida*, 8.4 mm., UMMZ No. 162738; C, *Gila robusta intermedia*, 9.2 mm., UMMZ No. 162841; D, *Tiaroga cobitis*, 10.5 mm., UMMZ No. 162754; and E, *Rhinichthys osculus*, 10.0 mm., UMMZ No. 162810.

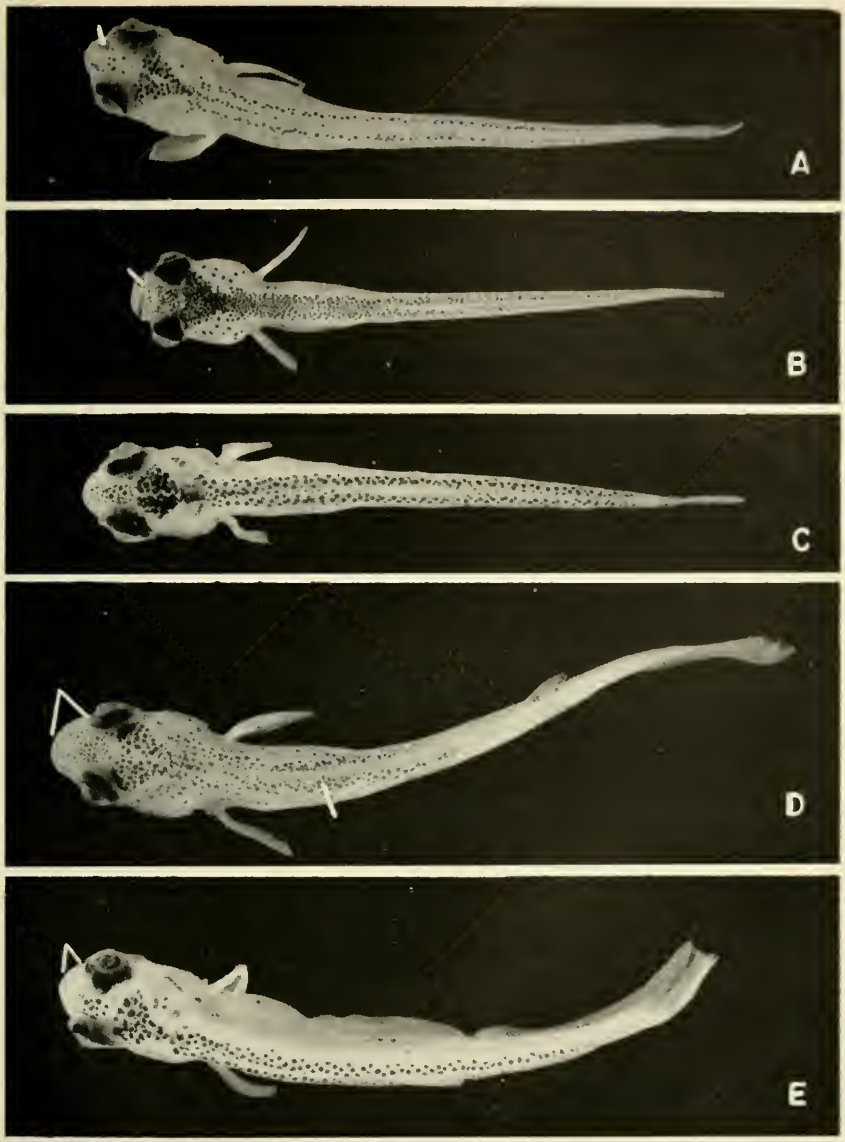

PLATE 2

Dorsal Views of Postlarval Minnows

A, *Agosia chrysogaster*, 9.3 mm., UMMZ No. 162705; B, *Meda fulgida*, 8.4 mm., UMMZ No. 162738; C, *Gila robusta intermedia*, 9.5 mm., UMMZ No. 162841; D, *Tiarogo cobitis*, 10.6 mm., UMMZ No. 162754; and E, *Rhinichthys osculus*, 9.4 mm., UMMZ No. 162810.

PLATE 3

Lateral Views of Postlarval Suckers

A, *Xyrauchen texanus*, 12.6 mm., UMMZ No. 162845; B, *Pantosteus delphinus utahensis*, 14.2 mm., UMMZ No. 162848; C, *Pantosteus* species, 12.4 mm., UMMZ No. 162830; D, *Pantosteus clarki*, 14 mm., UMMZ No. 162776; E, *Catostomus insignis*, 14.5 mm., UMMZ No. 162742; and F, *Catostomus latipinnis*, 14.2 mm., UMMZ No. 92248 (Wyoming).

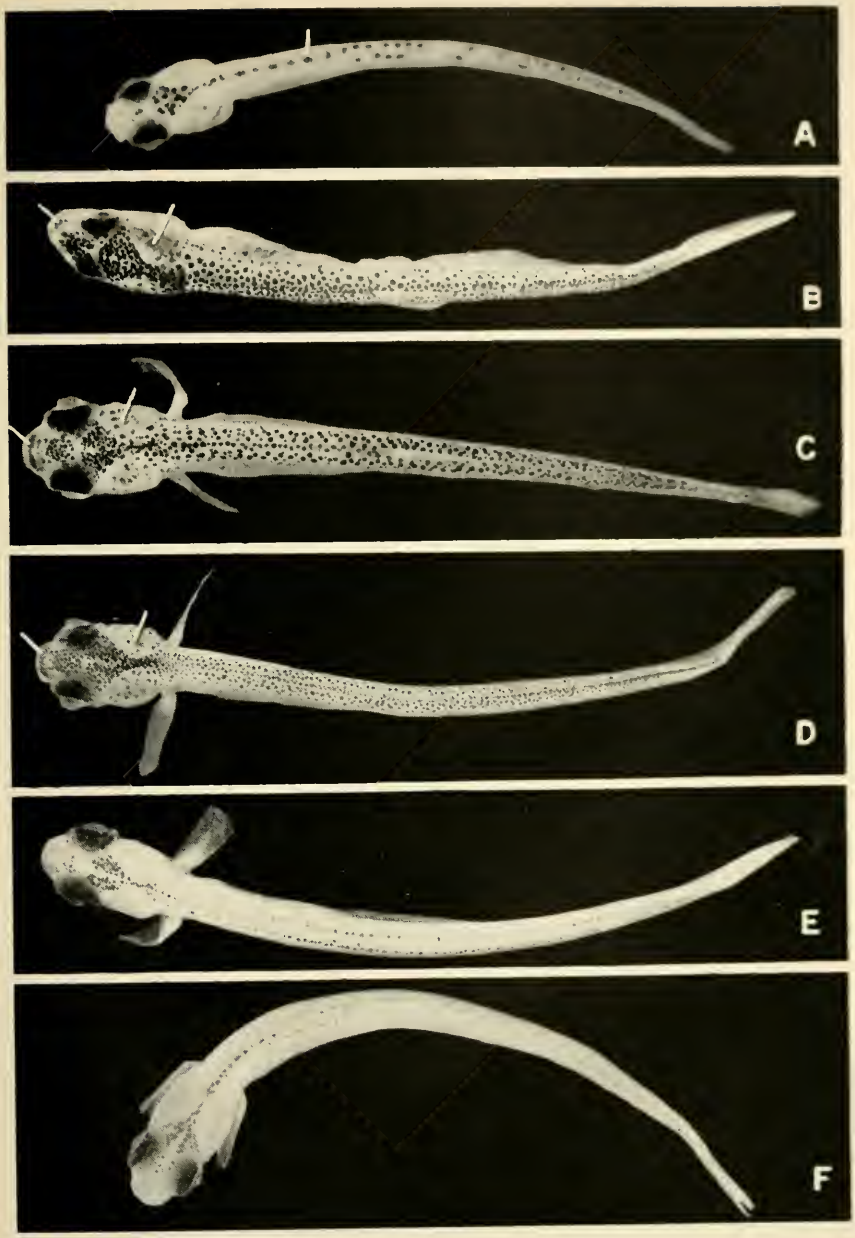

PLATE 4

Dorsal Views of Postlarval Suckers

A, *Xyrauchen texanus*, 10.5 mm., UMMZ No. 162845; B, *Pantasteus delphinus utahensis*, 14.2 mm., UMMZ No. 162848; C, *Pantasteus* species, 13.0 mm., UMMZ No. 162830; D. *Pantasteus clarki*, 12.3 mm., UMMZ No. 162809; E, *Catostomus insignis*, 13.8 mm., UMMZ No. 162742; and F, *Catostomus latipinnis*, 14.6 mm., UMMZ No. 92248 (Wyoming).

TABLE 1

Total Length in Millimeters at Which Certain Characters of Larval Minnows and Suckers Develop

Character	*Rhinichthys osculus*	*Agosia chrysogaster*	*Gila robusta**	*Meda fulgida*	*Tiaroga cobitis*
Opaque areas first appear in D. and A. fins	7.0— 7.5	±7.0	9.0— 9.5	7.5— 8.0	Before 10.2
D. and A. rays completely ossified†	10.5—12.0	10.5—11.5	12.0—14.0	+13.0	10.0—11.0
Pelvic buds appear	9.0— 9.5	10.0—11.0	±12.0	12.0—13.0	Before 10.2
Upturning of posterior tip of vertebral column	Before 7.6	±6.0	Before 9.0	±7.5	Before 10.2

Character	*Catostomus insignis*	*Catostomus latipinnis*	*Pantosteus clarki*	*Pantosteus delphinus*	*Xyrauchen texanus*
Opaque areas first appear in D. and A. fins	10.0—12.0	±11.5—12.5	11.5—12.5	11.0—11.5	±11.0
D. and A. rays completely ossified†	18.5— 20.5	18.5—20.5	±16.0	16.5—18.0	±17.0
Pelvic buds appear	16.5—17.5	15.5—16.5	15.0—16.0	15.0—16.0	±15.0
Upturning of posterior tip of vertebral column	Before 12.0	Before 12.0	Before 11.5	9.0—10.5	8.0— 9.0

* Includes *G. r. robusta* and *G. r. intermedia*.
† Dorsal rays start to ossify before anal rays

anal rays in both suckers and minnows, and ossifiation of the pectoral rays also occurs at this time. A peculiarity of the Catostomidae is that the opercuhum does not completely cover the gill arches until stages 37 to 39. *Catostomus commersoni* (Lacépède) also seems to fit this general picture (Stewart, 1926). The cyprinid stages of Balinsky may stand, therefore, as a basis for comparison of American minnows and suckers.

ARTIFICIAL KEY TO POSTLARVAL FISHES

Most of the characters described in the key that follows may be readily seen in the accompanying photographs (Plates 1-4). Difficulties were encountered at three points in the preparation of the key (items 4a, 8a, and 9a–9b). No small specimens of *Ptychocheilus lucius* were collected but it is assumed that they possess characteristics noted in late postlarval stages of *Ptychocheilus grande* and *P. oregonense*. Those two species have an oval internal pigment spot near the base of the upturned portion of the vertebral column, as in *Gila robusta*. Whether *Ptychocheilus* can be separated from *Gila* in earlier postlarval stages remains to be determined. To our knowledge, *Ptychocheilus* now occurs only in the main, swift flowing rivers (Colorado River, Salt River) and does not go up tributaries very far. Consequently, cyprinids from smaller streams that key out to item 4a can be identified with confidence as *Gila robusta*.

The species within the genera *Catostomus* and *Pantosteus* are often difficult to distinguish, even when adult. This problem is greatly multiplied when one attempts to key out the larval stages. We feel confident that the separation in the key between these genera is well founded, but it has not been possible to separate the species of *Pantosteus* and the distinction between *Catostomus insignis* and *C. latipinnis* is weak, although juveniles can readily be identified. In general, *C. latipinnis* seems to have less pigment than *C. insignis*. As with *Ptychocheilus*, few specimens of *C. latipinnis* have been recorded from the Gila River drainage in the past 50 years and, so far as we know, this species does not go far up the smaller tributaries. Consequently, suckers from the smaller streams that key out to item 9 may be determined provisionally as *C. insignis*.

Pantosteus dephinus, recorded here for the first time from the lower Colorado River system (Burro Creek, tributary to Big Sandy River, Mohave-Yavapai Co. line, Arizona; UMMZ 165920), has been taken only once in the Williams River drainage, tributary to the Colorado River at Parker Dam. It is evidently scarce there, whereas *Pantosteus* species is common.

1a. Distance from front of anus to end of caudal fin enters distance from anterior point of head to front of anus less than two times
Minnows, family Cyprinidae 2

1b. Distance from front of anus to end of caudal fin enters distance from anterior point of head to front of anus more than two times
Suckers, family Catostomidae 6

2a. Pigment on medial edges of nares concentrated as a single or double row of chromatophores. Internarial region largely unpigmented. Pigment line of horizontal myoseptum extending forward nearly to head
Agosia chrysogaster
(Pl. 1A, Pl. 2A)

2b. No distinct rows of chromatophores on medial edges of nares. Internarial region pigmented. Pigment line of horizontal myoseptum not extending far forward 3

3a. Mouth almost vertical. Horizontal myoseptum pigment line indistinct. Lateral pigment line formed of a band of widely scattered chromatophores, more distinct posteriorly ..... *Meda fulgida* (Pl. 1B, Pl. 2B)

3b. Mouth at most slightly oblique. Horizontal myoseptum pigment line distinct. Lateral pigment line not bandlike, comprising few scattered chromatophores 4

4a. A distinct, oval internal pigment spot at the base of the upturned caudal vertebrae. (See discussion of key) *Gila robusta* and *Ptychocheilus lucius* (Pl. 1C, Pl. 2C)

4b. No such distinct oval spot present 5

5a. Many scattered chromatophores over side of body above horizontal myoseptum pigment line; those along dorsal pigment line numerous and small. Snout not blunt ..... *Tiaroga cobitis* (Pl. 1D, Pl. 2D)

5b. Only a few scattered chromatophores on side of body; those in dorsal view larger and fewer. Snout blunt and, in later stages, with mass of pigment from eye to side of upper lip *Rhinichthys osculus* (Pl. 1E, Pl. 2E)

6a. Top of body covered with a few giant chromatophores; those in horizontal myoseptum form long dashes or are long and stellate *Xyrauchen texanus* (Pl. 3A, Pl. 4A)

6b. Chromatophores notably smaller and more numerous; those in horizontal myoseptum form short dashes or are round and stellate 7

7a. External chromatophores present below anterior part of horizontal myoseptum pigment line, extending downward over part of abdominal region. Edge of upper jaw and tip of lower jaw usually heavily pigmented. Many scattered chromatophores in space on each side of narrow posterior part of occipital pigment ..... *Pantosteus* 8

8a. Williams River drainage, western Arizona *Pantosteus delphinus* and *Pantosteus* species (Pl. 3B and C, Pl. 4B and C)

8b. Gila River drainage ..... *Pantosteus clarki* (Pl. 3D, Pl. 4D)

7b. No external chromatophores below anterior part of horizontal myoseptum pigment line. Edge of upper jaw and tip of lower jaw usually lightly pigmented (sometimes no pigment on tip of lower jaw in earlier stages). No chromatophores, or only a few in later stages, in space on each side of narrow posterior extension of occipital pigment *Catostomus* 9

9a. Typically with many chromatophores on caudal fin at all stages (rarely none or a few in earlier stages); usually more than four large chromatophores in midventral pigment line along isthmus anterior to bases of pectoral fins ..... *Catostomus insignis* (Pl. 3E, Pl. 4E)

9b. Typically lacking chromatophores on caudal fin (or a few in later stages); usually fewer than four large chromatophores (often none) in the midventral pigment line along isthmus anterior to bases of pectoral fins ..... *Catostomus latipinnis* (Pl. 3F, Pl. 4F)

REFERENCES

Balinsky, B. I.
1948. On the development of specific characters in cyprinid fishes. Zool. Soc. London, Proc., vol. 118, pt. 2, p. 335-341, 12 figs.

Douglas, Philip A.
1952. Notes on the spawning of the humpback sucker, *Xyrauchen texanus* (Abbott). Calif. Fish and Game, vol. 38, no. 2, p. 149-155, 4 figs.

Fish, Marie Poland
1929a. Contributions to the early life histories of Lake Erie fishes. N. Y. Cons. Dept., 18th Ann. Rept., 1928, Suppl., p. 76-95, 17 figs.
1929b. Contributions to the early life histories of Lake Erie fishes. Buffalo Soc. Nat. Sci. Bull., vol. 14, no. 3, p. 136-187, 53 figs.
1932. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. U. S. Bur. Fish., Bull., vol. 47, no. 10, p. 293-398, 144 figs.

Foerster, R. E., and A. L. Pritchard
1935. The identification of the young of the five species of Pacific salmon, with notes on the fresh-water phase of their life-history. Brit. Columb. Comm. Fish., Rept. 1934, p. K106-K116, 1 fig., 1 pl. (reprinted, 1944).

Fry, Donald H., Jr.
1936. Life history of *Hesperoleucus venustus* Snyder. Calif. Fish and Game, vol. 22, no. 2, p. 65-98, 9 figs.

Hubbs, Carl L.
1943. Terminology of early stages of fishes. Copeia, no. 4, p. 260.
1953. *Eleotris picta* added to the fish fauna of California. Calif. Fish and Game, vol. 39, no. 1, p. 69-76, 1 fig.

Kopec, John A.
1949. Ecology, breeding habits and young stages of *Crenichthys baileyi*, a cyprinodont fish of Nevada. Copeia, no. 1, p. 56-61, 2 figs.

Oppenheimer, J. M.
1937. The normal stages of *Fundulus heteroclitus*. Anat. Rec., vol. 68, no. 1, p. 1-15.

Orton, Grace L.
1953. The systematics of vertebrate larvae. Syst. Zool., vol. 2, no. 2, p. 63-75, 10 figs.

Stewart, Norman Hamilton
1926. Development, growth, and food habits of the white sucker, *Catostomus commersonii* LeSueur. U. S. Bur. Fish., Bull., vol. 42, p. 147-184, 55 figs.

Weisel, George F., and H. William Newman
1951. Breeding habits, development and early life history of *Richardsonius balteatus*, a northwestern minnow. Copeia, no. 3, p. 187-194, 8 figs.

ESTABLISHMENT OF A FORAGE FISH, THE RED SHINER *(NOTROPIS LUTRENSIS)*, IN THE LOWER COLORADO RIVER SYSTEM[1]

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It has been recognized for some time by those concerned with the fish management of the lower Colorado River that some of the numerous bait minnows brought in from diverse regions (Miller, 1952) may become established, for better or for worse, in the river and connected waters. Since the native fish fauna has become largely replaced by introduced game and pan fishes, as shown by the survey of Dill (1944, p. 144-146) and, more emphatically, by recent field work, it has been thought that the establishment of an essentially nonpredatory forage fish might increase the production of game fishes. It is therefore of interest and potential importance to note the recent establishment in the lower Colorado River system of such a forage fish, namely, the red shiner, *Notropis lutrensis* (Baird and Girard) (Figure 1). The name "red shiner" refers to the color of the body and more particularly of the fins, especially in the gorgeous breeding males. Because of its abundance and small size, this shiner is an important forage fish. It has also been valued as a home aquarium fish.

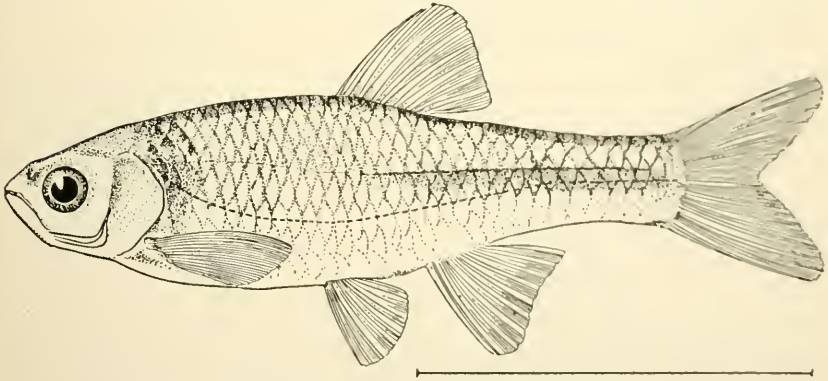

FIGURE 1. Red shiner, *Notropis lutrensis*, from Miller (1952).

THE ESTABLISHMENT

That the establishment has been recent is indicated by the lack of this species not only in the collections reported by Gilbert and Scofield (1898) and by Dill (1944), but also in more recent seining. In March, 1950, Robert Rush Miller, the author, and assistants collected in the

[1] Submitted for publication February, 1954. Contributions from the Scripps Institution of Oceanography, New Series, No. 715.

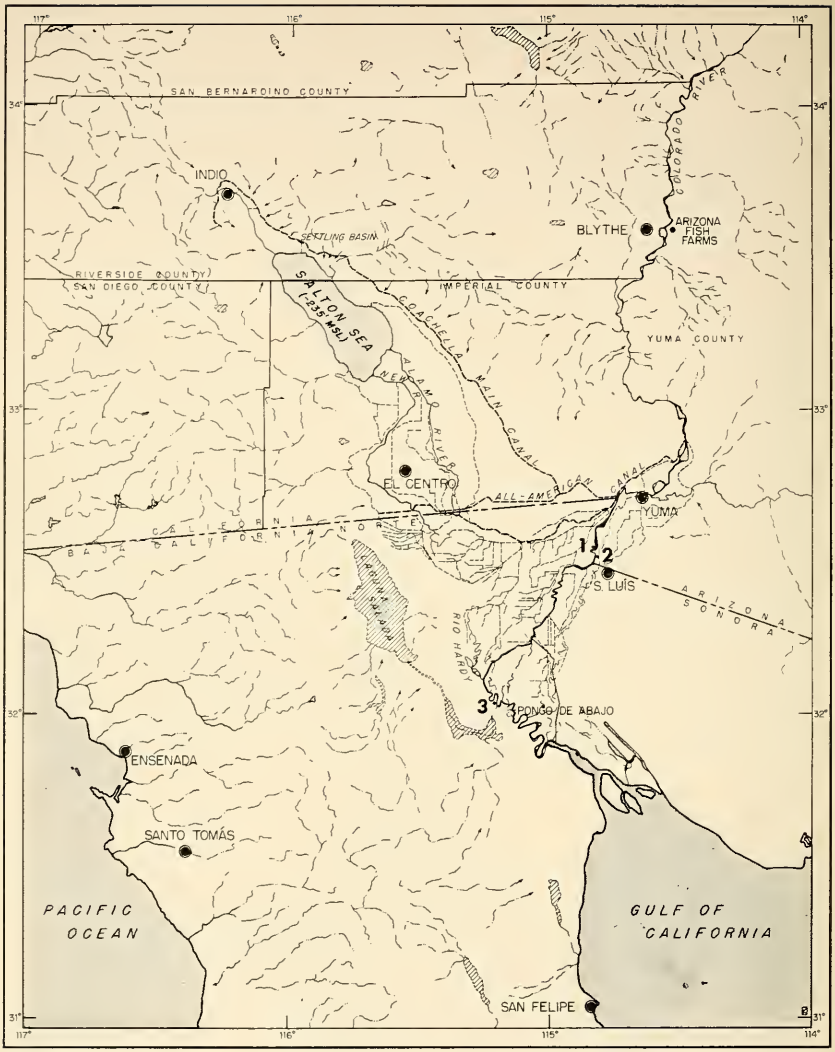

FIGURE 2. Sketch map of the lower Colorado River system, including the Delta and Salton Sink, showing by numbers where red shiners were taken along the river in 1953. Drafted by Robert G. Kirk primarily from state base maps and topographic sheets by the U. S. Geological Survey, from World Aeronautical charts, and from maps and data furnished by the International Boundary and Water Commission (Ing. José G. Valenzuela), Imperial Irrigation District (B. A. Weiss), and Coachella Valley County Water District (C. S. Hale).

lower Colorado River over the same region where the species was taken in January, 1953, but failed to obtain a single specimen of this species.

The first collections of the red shiner in the Colorado system were made by Kenneth S. Norris, A. A. Allanson, and party, during a boat trip down the main river undertaken for the author in January, 1953 (Figure 2). The first three collections contained specimens of this

species. Collection 1153-1, made in the river in Baja California Norte, 2 miles south of Gadsen, Yuma County, Arizona, on January 18, contained 149 young to adult specimens 17 to 46 mm. in standard length. Collection 1153-2, made in a backwater of the river in Arizona, 2 miles north of San Luís, Sonora, on the same day, included 9 half-grown to small adult specimens 20 to 31 mm. long. A single small adult 30 mm. long was seined at Station 1153-3, in the river in Baja California Norte an estimated 15 miles, by the Río Hardy slough and the river, below El Mayor, on January 20. Subsequent collections farther downstream (1153-4 to 7, 9, and 10), ranging from 2 miles above the Pongo de Abajo Ferry (which is directly east of a point on the San Felipe Highway 8.5 miles south of El Mayor) to the estuary about 10 miles by river above the mouth, contained no red shiners.

The next collection of the red shiner from the Colorado River system (W53-410), kindly made available by Dr. Boyd W. Walker, was taken by John E. Fitch and Wayne J. Baldwin on December 3, 1953, in one of the pools, then becoming dry, of the settling basin of the Coachella Valley County Water District, in Riverside County, California. This settling basin is 124.5 miles from the Colorado River *via* open earth-lined canal (36 miles along the All-American Canal and 88.5 miles on the Coachella Main Canal, which continues 37.5 miles farther as a concrete-lined open ditch). Between 500 and 700 of the shiners were taken in a tied-mesh minnow seine, but only 94 young to adult specimens, 15 to 50 mm. long, were preserved (Mr. Fitch reported some selection of larger fish). On December 15, while rescuing game fish in the same basin with a coarse-mesh seine, Richard D. Beland found one dead and

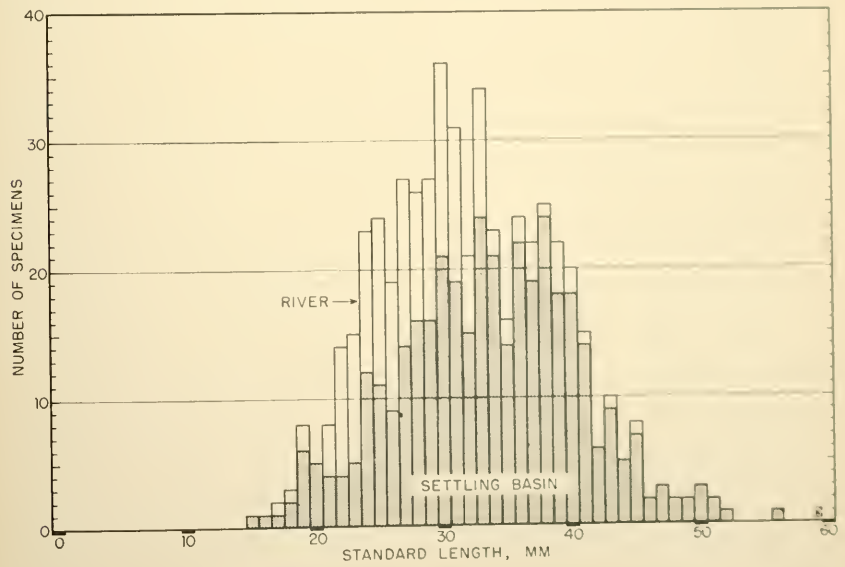

FIGURE 3. Size frequency distribution of red shiners collected in the settling basin of the Coachella Valley branch of the All-American Canal in December, 1953 (shaded columns) and in the lower Colorado River in January, 1953 (white columns).

one live specimen of the same shiner. On December 28 John E. Fitch, using a "Common Sense" minnow seine, obtained here a larger, unselected series, comprising 284 specimens 18 to 56 mm. long. The size frequencies, however, are approximately the same as for the December 3 collection.

That the species has rapidly become well established in the Colorado River and connected waters is indicated by the rather large number of specimens collected in 1953 in Arizona, Baja California Norte, and California, and by the widespread occurrence of young. The size-frequency distributions of the several collections (Figure 3) reveal that the red shiner in its new home breeds over a prolonged period, as it does in its native range (Hubbs and Ortenburger, 1929, p. 34; Ward, 1953, p. 20). By winter the young of the year, though in part still small, grade in size into the yearling and older groups. The rapid increase in numbers indicates that the new waters are well adapted to the species and emphasize anew the lack of faunal saturation in the western streams, particularly after the abrupt depletion of the limited native fish fauna. The Colorado River waters where the species has taken hold appear to be rather similar to the larger streams of Oklahoma and western Arkansas where it abounds, as well as in small streams of various types (Hubbs and Ortenburger, 1929). The annual fluctuation in the temperature of the Coachella Valley Branch of the All-American Canal, according to Mr. C. S. Hale, General Manager of the Coachella Valley County Water District, is from 48 to 86 degrees F. (probably the approximate range encountered by the species over much of its native territory).

There is circumstantial evidence that the lower Colorado system has become populated by red shiners through escapements from the ponds of the Arizona Fish Farms, Inc., at Ehrenburg, Arizona (near Blythe, California), though escaped or dumped bait may have contributed to the establishment of the species. The rearing of this minnow at the Arizona Fish Farms for the forage of channel catfish and for sale as bait has been reported by Miller (1952, p. 34). Richard D. Beland says (personal communication, 1953) that red shiners abound in some of the ponds, from which many have escaped into ditches on the Arizona side of the river, but that he has not taken the species in the river proper. A special effort by him to obtain specimens with rotenone in two small bays of an oxbow on the California side of the river, 2 miles north of the bridge at Blythe, on December 4, 1953, was not successful. His report (letter of December 11) adds: "I believe *N. lutrensis* was first propagated at the Arizona Fish Farms in 1948. They have been sold for bait along the river from Needles to Imperial Dam." Kirby H. Walker heard in 1949 that the spawning activities were under way for the second year. J. Bruce Kimsey reports (in letter dated December 17): "Mr. Hill of the Arizona Fish Farms near Blythe advised me large numbers of fry pass out through the screens into the river each time the brood ponds are drained, so its establishment seemed inevitable. A series of small minnows were noted by me on December 10, 1953 on a sand bar at Walker's Fish Camp, south of Blythe." Though these minnows were not sampled, it is highly probable that they were red shiners.

The stock of red shiners at the Arizona Fish Farms is reported to have come from the vicinity of Lake Buchanan in Texas (Miller, 1952, p. 34), on the basis of information furnished Dr. Miller and me by Kirby H. Walker, who had consulted with officials of the company. Lake Buchanan is a reservoir on the Colorado River (of the Gulf of Mexico drainage), in Llano and Burnet counties, Texas.

IDENTIFICATION

The identification of these shiners as of the species *Notropis lutrensis* (Baird and Girard) is indubitable. The characters agree fully with those of the species and in nearly all respects with those of the typical subspecies, the Plains red shiner (*N. l. lutrensis*), as these characters have been determined by me (in Hubbs and Ortenburger, 1929, p. 33-34, 73-76; and in MS) and by Clark Hubbs, who, at the University of Texas, is conducting statistical and experimental studies on this species and its close relatives and is considering the status of its subspecies. The anal rays (Table 1) are typically 9, rarely 8 or 10. The

TABLE 1

Anal Ray Counts of Red Shiners in the Lower Colorado River System

Locality	Anal rays			No.	Mean
	8	9	10		
River in Arizona and Baja California	18	130	5	153	8.91
Settling basin of Coachella Valley Canal	5	81	5	91	9.00

lateral line scales in 10 river specimens vary from 32 to 34 and average 33.33; in 30 specimens from the basin of the Coachella Valley Irrigation Canal, from 33 to 36, average 34.07. The slight difference in scale counts, as of anal ray counts, may be due to small-sample error or to direct environmental effects. The mouth is nearly straight and is strongly oblique, rising anteriorly about to the level of the middle of the pupil. The lips are not markedly thickened. The midventral black streak on the head of the adults is confined to the space between the mandibular rami. The general color is pale, with the pigment rather well spread over the scale pockets, with the lateral dark band weak, diffuse, and obsolescent anteriorly on the trunk and head, and with the lower sides unpigmented or lightly pigmented. The dark shoulder bar is well developed. The arrangement of the nuptial tubercles of the males is not evident on the specimens at hand, all of which were obtained in the winter. The young are pigmented like Oklahoma and Arkansas specimens described by Hubbs and Ortenburger (1929, p. 76), except that a middorsal file of melanophores is usually more or less evident, especially behind the dorsal fin, and the lateral dark band is obsolescent anteriorly.

Identification to subspecies is complicated by the fact that the stock came from a region in Texas where *Notropis lutrensis lutrensis* appears to intergrade with a form of the southern coastal plain of Texas that may well rank as a distinct subspecies, which would probably bear the name *Notropis lutrensis suavis* (Girard). Compared with typical *N. l. lutrensis* this local form ordinarily has a slenderer body, smaller fins, and, in the ripe males, fewer tubercles. It also usually has a slightly reduced average number of anal rays, about 8.7 rather than about 9.2. The depth of the body seems to provide the best distinction. Clark Hubbs has provisionally determined that, as a rule, the distance from the dorsal origin to the anal origin in the adult males is less than .31 of the standard length in *N. l. suavis* and more than .33 in *N. l. lutrensis;* in the adult females, less than .29 in *suavis* and more than .30 in *lutrensis.* In this respect the specimens from the settling basin of the Coachella Valley Branch of the All-American Canal, taken December 28, agree rather well with *suavis:* in 38 males 37 to 56 mm. long the distance between the origins of the dorsal and anal fins measures .25 to .30 of the standard length, with an average of .278; in 31 females 37 to 51 mm. long, .25 to .29, with an average of .273. But many of the specimens were small adults, none were breeding, all were taken in the winter, and some showed a degree of parasitism and emaciation that could be attributed to crowding in desiccating waters. The number of anal rays (Table 1) is intermediate. These determinations, and more especially the circumstance that Clark Hubbs has identified material from the source region of our stock as intergrades between *suavis* and typical *lutrensis,* lead me to identify the introduced stock provisionally as intergrades (*Notropis lutrensis: lutrensis* × *suavis*).

The specimens from the settling basin are indicated as even more slender when the greatest depth is stepped into the standard length. In 113 of the largest specimens taken on December 3 and 28, divided about equally between the sexes, this measurement is 3.7 to 4.7, with an average of 4.29. For Illinois specimens Forbes and Richardson (1920, p. 144, col. pl. opp. p. 143) give: "depth 2.7 to 3.2 in adults, the young more slender."

The retention of the slender form in various habitats where the species has been established in the lower Colorado River system, in places where competition is presumably slight and food probably plentiful, provides strong evidence that the slenderness of the form called *N. l. suavis* is genetically determined, though the possibility remains that the body form may be determined, at least in part, by the environment, interacting with hormones. The depth of the body in *N. lutrensis* is subject to wide fluctuations, both individual and regional, and increases with age, especially in the males. These fluctuations are largely responsible for the abnormally long synonymy borne by the species (Hubbs and Ortenburger, 1929, p. 74-75).

The genus *Notropis* has not previously been reported from either California or Baja California Norte and the species is new for these states and for Arizona. The native range of *Notropis l. lutrensis* is from Illinois and South Dakota westward and southwestward through the Great Plains, with the southern limit in the Río Grande, Río San Fernando, and Río Soto la Marina systems of the Atlantic drainage of

northeastern México. One localized subspecies, *Notropis lutrensis blairi* Hubbs (1940, p. 6-8), has been described from Texas. It may prove to be a distinct species; on the other hand, some of the nominal species now recognized from the disrupted segments of the Río Grande complex on the Sonoran Plateau of northern México may on more critical study be regarded as subspecies of *N. lutrensis*. Because of the inconsistency of its two chief features, the slender body and the large eye, I now treat as *N. lutrensis forlonensis* Meek the form inhabiting the Río Pánuco system in mideastern México that has been called *N. forlonensis*.

It is obvious that the material under discussion is not referable to *Notropis mearnsi*, which was described from the Río Yaqui system in Sonora by Snyder (1915, p. 582-584, fig.) and has since been taken in the same system in Arizona (Miller and Simon, 1943). As Snyder indicated, that form has smaller scales (about 10 in the lateral line) and usually only 8 anal rays. The same kind, or complex of similar forms, occurs in other Mexican tributaries of the Gulf of California. It should probably be called *N. formosa mearnsi* Snyder. *N. formosa formosa* (Girard) is one of the forms in the interior drainage of the Sonoran Plateau, itself perhaps only subspecifically differentiated from *N. lutrensis*.

The red shiner may be recognized, at least as an adult, by comparison of specimens with the colored plate in Forbes and Richardson or with the figure given by Miller (1952, p. 21), reproduced herewith as Figure 1. Miller's figure shows well the characters visible in side view, except for the black stippling of the interradial membranes of the dorsal fin. The slenderer body of the introduced form must be kept in mind in comparing specimens with the published figures.

SUMMARY

The red shiner, *Notropis lutrensis* (Baird and Girard), native from the North Central States to northeastern México, has recently become established in the Colorado River and connected waters of Arizona, Baja California Norte, and California, where it is of potential importance in game fish management. The recent great depletion of the limited native fish fauna accounts for the rapid increase of this and other introduced fishes in the lower Colorado River system. The establishment of the red shiner is attributed to escapements from the Arizona Fish Farms near Blythe, California. The stock came from near Lake Buchanan, Texas. The introduced fish are provisionally regarded as intergrades between *N. l. lutrensis* and *N. l. suavis*, a slender race of the southern coastal plain of Texas. They are not *N. mearnsi* Snyder, a form of the Gulf of California drainage that should probably be treated as a subspecies of *N. formosa* (Girard). That form and certain other nominal species, of the interior drainage of the Sonoran Plateau, may also prove to be interpretable as subspecies of *N. lutrensis*. *Notropis forlonensis* of the Río Pánuco system in eastern México is definitely so regarded.

ACKNOWLEDGMENTS

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REFERENCES

Dill, William A.
1944. The fishery of the lower Colorado River. Calif. Fish and Game, vol. 30, no. 2, p. 109-211, figs. 45-82.

Forbes, Stephen Alfred, and Robert Earl Richardson
1920. The fishes of Illinois. 2nd ed. Ill. Nat. Hist. Survey, vol. 3, cxxxvi + 357 p., 76 figs., 68 pls.

Gilbert, Charles Henry, and Norman Bishop Scofield
1898. Notes on a collection of fishes from the Colorado Basin in Arizona. U. S. Nat. Mus., Proc., vol. 20, p. 487-499, pls. 36-39.

Hubbs, Carl L.
1940. Fishes from the Big Bend region of Texas. Tex. Acad. Sci., Trans., vol. 23, for 1938-1939, p. 3-12.

Hubbs, Carl L., and A. I. Ortenburger
1929. Further notes on the fishes of Oklahoma with descriptions of new species of Cyprinidae, *and* Fishes collected in Oklahoma and Arkansas in 1927. Univ. Okla. Biol. Surv., Publ., vol. 1, nos. 2-3 (in: Univ. Okla. Bull., new ser., no. 434), p. 15-112, pls. 1-13.

Miller, Robert Rush
1952. Bait fishes of the lower Colorado River from Lake Mead, Nevada, to Yuma, Arizona, with a key for their identification. Calif. Fish and Game, vol. 38, no. 1, p. 7-42, figs. 1-32.

Miller, Robert Rush, and James R. Simon
1943. *Notropis mearnsi* from Arizona, an addition to the known fish fauna of the United States. Copeia, 1943, no. 4, p. 253.

Snyder, John Otterbein
1915. Notes on a collection of fishes made by Dr. Edgar A. Mearns from rivers tributary to the Gulf of California. U. S. Nat. Mus., Proc., vol. 49, p. 573-586, 1 fig., pls. 76-77.

Ward, H. C.
1953. Know your Oklahoma fishes. Okla. Game and Fish Dept., 40 p., 37 figs.

TAGGING EXPERIMENTS ON THE YELLOWTAIL, *SERIOLA DORSALIS* (GILL)[1]

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INTRODUCTION

The yellowtail is one of Southern California's most prized marine game fishes because of its fighting qualities. Few others afford more thrill to anglers and consequently it is sought extensively, particularly by the sportfishing boats at San Diego. Records of the anglers' catch, kept by recreational fishing boat operators, show that since 1947 the average landings have been about 22,000 fish per year. Sportsmen have become increasingly concerned over the supply and their concern led directly to the establishment of this investigation.

Yellowtail are also valuable to commercial fishermen, and are marketed canned, smoked, or fresh. Boats seldom make trips specifically for yellowtail, but they do take considerable quantities incidental to other fishing or when more desirable species are not available. The average commercial landings since 1947 have been 7,500,000 pounds per year (about 75,000 fish).

Yellowtail have been recorded from Monterey Bay in Central California but are rare north of Los Angeles County. To the south they are found along the Baja California coast and in the Gulf of California. By far the greatest abundance occurs in Mexican waters, and California is on the fringe of the population. Almost the entire commercial catch is taken between Cedros Island and Magdalena Bay. Sport fishermen take yellowtail primarily during the spring and summer months along the Southern California mainland coast and around Santa Catalina and San Clemente Islands. In recent years, however, the best catches have been made at the Coronados Islands, just south of the Mexican border.

Full-scale yellowtail investigations were started in January, 1952. The first and major problem has been to determine whether these highly prized fish move from Mexican waters, where they are most abundant, into California waters. This question can be answered most directly by the results of a tagging program. Marking yellowtail has, therefore, been the largest single undertaking of the investigation. It was felt that considerable experimental work should be done to find the mark best suited for these fish. Consequently, a great deal of time was devoted to testing of tags during 1952 and 1953.

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Four types of experiments were conducted:

1. Double tagging at sea to obtain information on the relative merits of various tags, as well as data on migrations.
2. Observing tags on live yellowtail in an aquarium.
3. Testing the staying qualities of tags on fish in a high-speed water tunnel.
4. Testing the physical effects on tags of a prolonged period on the bottom of the department's survey vessel, N. B. Scofield.

This report is concerned primarily with these tests, which have resulted in the development of suitable tags. The program is now devoted to marking a sufficiently large number of fish to provide the necessary information on migrations.

RESUMÉ OF EXPERIMENTS

Tagging at Sea

By the end of February, 1954, 3,147 yellowtail had been tagged and released and 103 recovered (Table 1). Most of the fish (2,314) were double tagged, using Petersen disks as the basic mark in conjunction with one of the following:

1. Plastic, diamond-shaped tag, stapled to the operculum.
2. Cellulose nitrate strap tag on the operculum.
3. Streamer tag.
4. Jaw tag.
5. Vinylite tubing tag.

TABLE 1

Release and Recovery Data for Tagged Yellowtail

Data Are Complete Through February, 1954 (See Figure 9)

Date	Place of release	Number tagged	Number recovered
June-Sept., 1951	Coronados Islands	4	1
	La Jolla, California	1	0
	Guadalupe Island	11	0
	Totals	16	1
1952	Coronados Islands	18	7
	Guadalupe Island	380	11
	Cedros Island-Abreojos Pt.	87	8
	Totals	485	26
1953	Coronados Islands	9	4
	Guadalupe Island	268	13
	Cedros Island-Abreojos Pt.	76	2
	Abreojos Pt.-Magdalena Bay	1,685	57
	Gulf of California	14	0
	Totals	2,052	76
Jan.-Feb., 1954	Baja California 25° 44′ N. to 27° 30′ N.	594	0
	Grand Totals	3,147	103

The double tagging experiments made it possible to compare the staying qualities of the various marks in order to determine which were the most satisfactory for future use and at the same time gave some knowledge of movements.

Aquarium Experiment

Eighteen live, marked yellowtail were placed in an aquarium at the Scripps Institution of Oceanography in late January, 1952. All but five survived until mid-June, 1952, when, unfortunately, an aquarium accident resulted in their death.

The tags apparently irritated the fish to some degree. For example, a fish, with a sudden burst of speed, would swoop upside down along the bottom, trying to rub off the marks. There were several marine turtles in the tank and the fish frequently scraped their backs across the ridges of the turtles' carapaces.

Yellowtail are semipelagic, being found over shallow banks and rocky shoals. Sometimes whole schools are near the surface, and at other times they are found only at the bottom. Their habitat, together with their observed tendency to rub their backs against solid objects, makes it obvious that the tags must be rugged and well secured.

The following types of tags were observed in the aquarium experiment:

1. Petersen disks attached by:
   a. Stainless steel wire;
   b. Monofilament nylon line.
2. Plastic diamond-shaped plates stapled to the operculum.
3. Nickel strap tags attached to the operculum.
4. Cellulose nitrate strap tags attached to the operculum.
5. Jaw tags.
6. Streamer tags.
7. Hydrostatic tags.

Acknowledgment is made to the Scripps Institution of Oceanography for provision of an aquarium tank and for the care of the fish during this experiment.

Water Tunnel Experiment

The work of Alverson and Chenoweth (1951) in testing the effect of water velocity on albacore (*Thunnus germo*) tags suggested that similar results might prevail with yellowtail. Both fish are capable of short bursts of considerable speed, and it seems quite plausible that the velocities at which they swim might easily exert sufficient force to tear tags loose.

Messrs. Alverson and Chenoweth readily agreed to test our fish, and their cooperation and help are gratefully acknowledged. In March, 1952, five yellowtail were shipped frozen to Seattle, Washington, where

they were tested at the University of Washington Hydraulics Laboratory. The following tags were used in the experiment:

1. Petersen disks attached by:
   a. Stainless steel wire;
   b. Monofilament nylon line.
2. Petersen disks riveted to the opercular bone.
3. Nickel opercular strap tags.
4. Streamer tags.
5. Hydrostatic tags.
6. Vinylite tubing tags attached through the back.

Test on Bottom of Vessel

On July 24, 1953, samples of jaw tags and tubing tags were attached to two pieces of rubber hose in a manner similar to their attachment on a yellowtail. The hoses were then secured to the bottom of the N. B. Scofield, one section about 60 feet aft of the bow and the other just under the counter of the stern. The tags under the stern received reflected light and were completely submerged only when the after bait tanks were full. The tags were untouched until December 11, 1953, $4\frac{1}{2}$ months later, when the vessel was put in dry dock for overhaul. During this time the N. B. Scofield covered approximately 4,200 miles, most of the distance through waters frequented by yellowtail. The cruising speed of the vessel is a little less than 10 knots. None of the tags came off, and all remained in excellent condition.

TYPES OF TAGS USED

Petersen Disks

The Petersen disks were identical with those used extensively in other marking experiments conducted by California workers (Calhoun, 1952; Calhoun et al., 1951; Collyer and Young, 1952). They were made of three layers of laminated cellulose nitrate one-half inch in diameter and 0.040 inch thick (Figure 1). The center layer was red and the protective outer layers transparent. The legend was printed on the center layer.

In the yellowtail experiments, the tags were applied in pairs, one on either side of the fish, by means of a wire or line passing through the body, just under the anterior insertion of the soft dorsal fin. One disk bore the legend and the other was blank. Two plastic spacers (Figure 2), each 0.040 inch thick, were used, one under each Petersen disk, to assure that the tags were not secured too tightly. Two materials were used to attach the tags. Type 302, 0.032-inch diameter, soft temper, stainless steel wire was used between June, 1951, and April, 1952, and various types of monofilament nylon fishing line thereafter.

Throughout most of the program, double strands of 18-pound test, 0.021-inch diameter nylon line were used. Limited field trials were made in July, 1952, and September, 1953, with single strand 40-pound test, 0.032-inch diameter line. The initial supply of 18-pound test nylon was quite stiff and hard to handle, but it was the only type available during most of 1952. A softer variety, said to have all the qualities of

FIGURE 1. Petersen disks, showing the knots. The blood knot (right) was tied in advance of tagging operations and threaded through the numbered disk. The turban knot (left) was the final tie which secured the tags to the fish.

FIGURE 2. A double-tagged fish, showing the tubing tag in position and the Petersen disks being affixed. The spreader plates, which are removed before releasing the fish, are shown under the Petersen disks. *Photograph by Claude Kreider, September, 1953.*

the original material and much easier to use, was put on the market in late 1952. Most of the nylon used in 1953 was the soft, more flexible type.

The blood knot (Young et al., 1953) was the initial tie with nylon. The final securing was done with a double overhand knot until the September, 1953, tagging trip on the N. B. Scofield. On this cruise 24 double-tagged fish, which had been released only a month before, were retaken, and all but four had lost their Petersen disks. Although we could not be sure, it appeared that the knot was failing. The turban knot (Young et al.) was then substituted for the overhand.

Aquarium Experiment

On these fish nine sets of Petersen disks were attached by stainless steel wire and three sets by 0.021-inch monofilament nylon. Of the nine sets of wire-secured disks, seven were retained for the duration of the experiment, 147 days, and two sets tore loose after 1½ months and four months, respectively. In all cases, the wire bent so that the tags were perpendicular to the flow of water, and those in place at the end of the experiment were tearing and irritating the tissue through which the wire passed. The disks attached by nylon were placed on the fish March 7, 1952. Two sets of disks lasted the remainder of the experiment, 104 days, and were still in good condition when the fish died. The third set came off in 66 days, but neither the tags nor the nylon were found, and thus there is no explanation for the failure. These tags were all secured with hard nylon, using the blood knot on one side and the double overhand knot on the other.

Water Tunnel Experiment

The staying qualities of four sets of Petersen tags were tested. Three pairs of disks attached by stainless steel wire remained on the fish for the duration of the runs. One pair stood the maximum test of 12 minutes at 25 to 29 miles per hour. However, like similar tags on the aquarium fish, they all bent perpendicular to the flow of water, and the process of tearing the tissue had started. The fourth set of disks, attached by 0.021-inch diameter hard nylon, broke loose before conclusion of the test. The cause of loss was failure of the nylon, but whether it was due to breakage or to the knot coming loose is unknown.

Tagging at Sea

The number of yellowtail released at sea with Petersen disk tags, regardless of attachment, totals 2,463, of which 2,314 were double-tagged. There have been 26 recoveries and 66 known losses from double-tagged fish (Table 2) and eight recoveries from the 149 single-tagged fish.

Disks attached by wire were used on 71 fish, all of which were single-tagged. The six recoveries have made the best showing in terms of the number of days retained: 38 to 225, with an average of 151 days. However, wire was used only during January and February, 1952, at which time of year there was little or no yellowtail fishing in the area where they were released. The returns, all but the one out 38 days, occurred in late summer and fall, which coincides with the fishing season. None were taken in 1953.

TABLE 2

Tags Returned and Those Known to Have Been Lost From Fish Double tagged in 1952 and 1953

Tagging combination	Fish tagged	Fish returned	Data on tags		
			Both tags returned	Petersen disks lost	Other tag lost
Petersen disks attached by two strands of 18 lb. test nylon, double overhand knot, with:					
Diamond opercular tags	77	7	1	5	1
Opercular strap tags	107	4	1	0	3
Streamer tags (type D)	196	13	6	5	2
Jaw tags	118	15	2	13	0
Tubing tags	390	21	8	13	0
Totals	888	60	18	36	6
Petersen disks attached by two strands of 18 lb. test nylon, turban knot, with:					
Jaw tags	11	0	0	0	0
Tubing tags	1,388	31	1	30	0
Totals	1,399	31	1	30	0
Petersen disks attached by a single strand of 40 lb. test nylon, turban knot, with:					
Tubing tags	27	1	1	0	0
Grand Totals	2,314	92	20	66	6

Petersen disks attached with nylon made a poor showing in 1952. The 12 returns were out an average of 64 days with a range of from 5 to 188 days. Nine sets of disks on double-tagged fish were known to have been shed, and there were no returns in 1953.

The 1953 results were even more unsatisfactory, the 20 returns averaging only 39 days out with a range of from 11 to 81 days. The losses far exceeded the tags retained; 57 fish were recaptured with the alternate tag intact and the Petersen disks gone.

Evaluation

The aquarium observations, the water tunnel tests, and the field experiments have all shown that Petersen disk tags are unsatisfactory for marking yellowtail. The use of wire left much to be desired; the hard nylon was unsatisfactory. Soft nylon appeared to be worse and changing the knots did not reduce the losses. The use of Petersen disks has been discontinued.

Diamond Opercular Tags

These diamond-shaped tags were made of cellulose nitrate, 1 by $\frac{3}{4}$ by 0.040 inches, and were attached to the opercular bone by a staple passing through two rectangular holes (Figure 3). The staples were bent from pieces of type 302 stainless steel, $1\frac{1}{2}$ by $\frac{1}{4}$ by 0.020 inches, and were covered by protective sheaths of polyvinyl chloride tubing.

The tags were fairly easy to apply. Two holes were punched through the operculum, the right width and size to fit the staple. The staple

was passed through the holes from the inside and was clinched over the plastic plate on the outside with pointed-nosed pliers. Care was taken not to squeeze too tight.

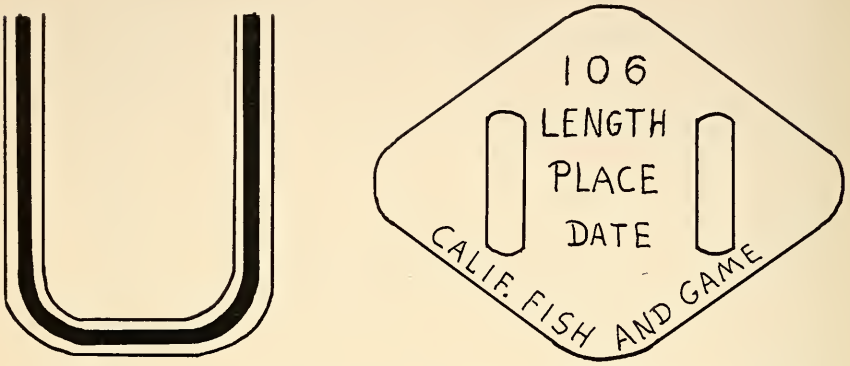

FIGURE 3. Diamond opercular tag. The words LENGTH, PLACE, DATE were inscribed as o notice to fishermen; space limitations prevented more detailed instructions.

Aquarium Observations

In the aquarium, one diamond staple tag lasted a little less than a month, one a month and a half, and a third just a few days less than two months. All the tags tore through the operculum, leaving gaping holes.

Water Tunnel Experiment

Three tags similar to the diamond staple tag were tested. These consisted of single Petersen disks riveted to the operculum with a soft temper, type 303, stainless steel rivet. This tag was an adaptation of that used by Cable (1950) on shad. Tag 1 came off after $7\frac{1}{4}$ minutes of a $12\frac{1}{2}$-minute run at 20 to 25 miles per hour. Tag 2 lasted through a 10-minute run at 20 to 29 miles per hour but worked considerably and would not have remained much longer. Tag 3 came off after $3\frac{1}{2}$ minutes of a 12-minute test at a maximum velocity of 29 miles per hour.

Tagging at Sea

The 77 diamond opercular tags used in conjunction with Petersen disks yielded six recoveries (Table 2). The time out ranged from 5 to 95 days, with a mean of 40 days. There was one known loss on a fish which retained the disks for 172 days.

Evaluation

Neither the diamond opercular tag nor the Cable-type tag yielded satisfactory results. In addition, there was the possibility of their not being seen by fishermen because they were visible from only one side of the fish. Further use of these tags on yellowtail has been abandoned.

Opercular Strap Tags

Two kinds of opercular strap tags were tried. Nickel tags, 19 by 4 by 0.7 mm., designed for Pacific mackerel, *Pneumatophorus diego*, (Fry and Roedel, 1949), were used in the aquarium and water tunnel experiments. The second type (Figure 4) was made of cellulose nitrate strips measuring 3 by $\frac{5}{8}$ by 0.040 inches. A legend was printed on the plastic with a rubber stamp, using ink containing a solvent for cellulose nitrate (California Ink Company No. 104N5A2). The serial number was written at one end of the legend with a steel pen. The strips were dipped in boiling water to soften them, and then bent into a flat elongated "I" shape with an overlapping flange, so that the tag could be snapped in place, much like securing the latch of a safety pin. The shape of the tag was then set by dipping in cold water.

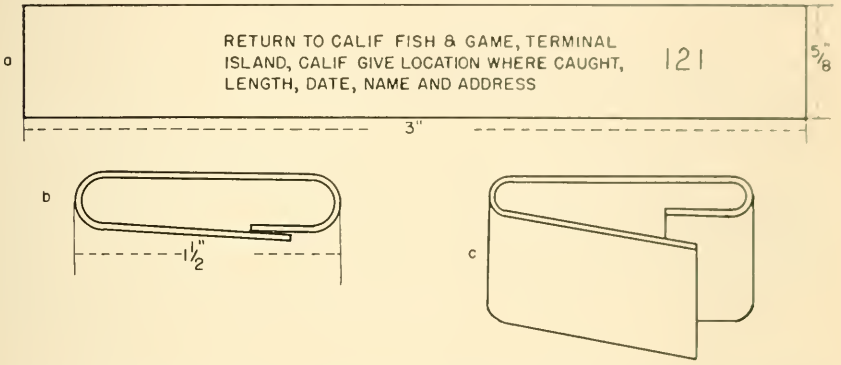

FIGURE 4. Opercular strap tag. a. Plastic strip showing legend and number, before bending; b. End view, showing latch closed; c. Face view, showing latch open.

Application of the nickel tag was with special pliers, as described by Fry and Roedel. The plastic tag was applied as follows: A small slit was cut through the operculum at a distance from its posterior margin equal to the length of the tag. The straight portion of the tag was inserted through the slit from under the gill cover. The tag was then rotated through 180 degrees, so that the end opposite the flange lay in the slit and the flange lay at the posterior margin of the operculum.

Aquarium Observations

Four nickel strap tags and one cellulose nitrate strap tag were observed. The nitrate strap tag was in good condition a month after being put on, when the fish became sick and was released. The first mackerel tag to come off did so in 2½ months, and the last came off in five months. In all cases the tags worked posteriorly through the opercular bone.

Water Tunnel Experiment

Three nickel strap tags held well through the water tunnel tests. None showed signs of coming loose.

Tagging at Sea

Cellulose nitrate strap tags were applied to 107 fish in conjunction with Petersen disks. Of four recoveries, three had lost the strap tag, and the single fish retaining it was at liberty only 23 days (Table 3).

Evaluation

The use of strap tags, like the other opercular tags, has been discontinued. Almost all indications were that the opercular bone was too weak to hold the tag.

Jaw Tags

The jaw tags (Figure 5) used in the experiments differed only in shape from the plastic opercular strap tags. In fabricating them, the softened strips were bent around a wooden jig to the approximate shape of a yellowtail's lower jaw.

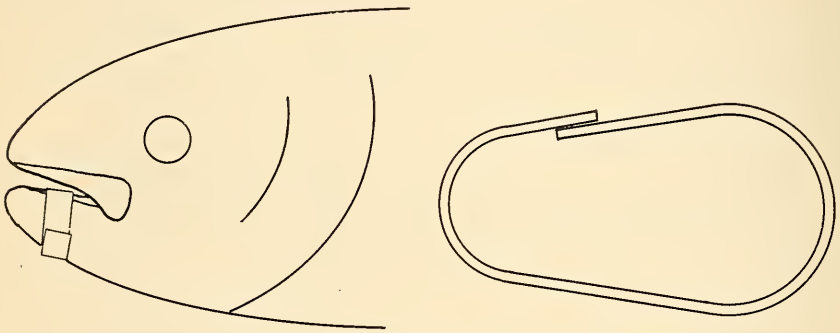

FIGURE 5. Jaw tag.

Jaw tags are still being used, but are now made from laminated sheets of cellulose nitrate with machine-printed legends on the red center layer. The new tags are larger, 4 by $\frac{5}{8}$ by 0.050 inches as against 3 by $\frac{5}{8}$ by 0.040 inches. They are shaped in the same manner as were the old.

In securing the tag, the isthmus between the lower jaw (dentary) and the tongue support (hyal assembly) is slit about one inch. A dull knife works satisfactorily and is much safer for the tagger in case the fish makes a sudden lurch. The tag is inserted through the slit from the ventral side with the flange up and on the outside of the fish. It is then turned around the dentary bone and snapped into place with the flange down and on the outside.

Aquarium Observations

Only one jaw tag was tested in the aquarium. It was applied April 21, 1952, and stayed in place until the termination of the experiment June 19, 1952, with no sign of distress to the fish.

Water Tunnel Experiment

No jaw tags were tested in the water tunnel.

Test on Bottom of Vessel

Four tags, attached to two rubber hoses on the bottom of the N. B. Scofield, held perfectly. The only fault appeared to be fading and possibly wearing of the printing; however, all were still legible after 4½ months.

Tagging at Sea

Jaw tags were used in conjunction with Petersen disks on 129 fish. Fifteen of these fish have been recaptured with no loss of jaw tags (Table 2). There was no soreness nor evidence that the tags would not have stayed in place for some time. However, there was some indication that the legends were fading. Only two sets of the Petersen disks were retained. The number of days out ranged from 2 to 86, with a mean of 37½.

Evaluation

The jaw tags have proved very satisfactory and their use is being continued. The tags are conspicuous and show from almost any angle. They are easy to attach and may be applied faster than any of the others, with the possible exception of the streamer tag.

The hand-made tags used in the experiments had only one fault: The legend, being exposed, was subject to fading or wear. Definite evidence was obtained from the tubing tag tests that the ink used on them and on the jaw tags would fade (page 309). The ink on the new jaw tags is believed to be far more durable, and the lamination will protect the printing from wear.

Streamer Tags

Two types of streamer tags were tested: the Einar Lea hydrostatic tag (Cons. Perm. Internat., 1953) and a tag similar to the "type D" mark (Figure 6) which was used on tuna (Wilson, 1953). Several methods of making the latter tag were tried. A message printed on a piece of waterproof paper ½ by 2¼ inches was rolled tight around one

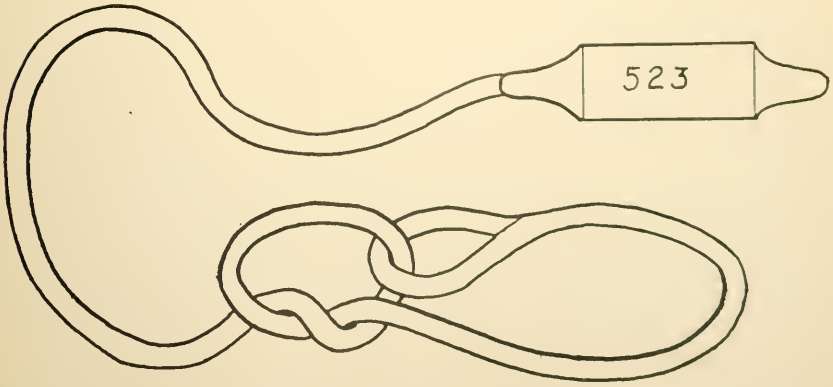

FIGURE 6. "Type D" streamer tag.

end of an 11-inch length of braided nylon line. On the other end of the line was a loop one inch in diameter. At first the message was enclosed in a short length of nylon tubing, about $\frac{5}{8}$ inch long. The whole message end was then dipped in soluble nylon to give it a tough protective coating. Later the tube was eliminated. The message was then rolled around the end of the braided line and twisted into a small piece of polyethylene film, just enough to hold it, and then dipped in the soluble nylon as before. The new method of fabrication resulted in lighter tags that were simpler to make.

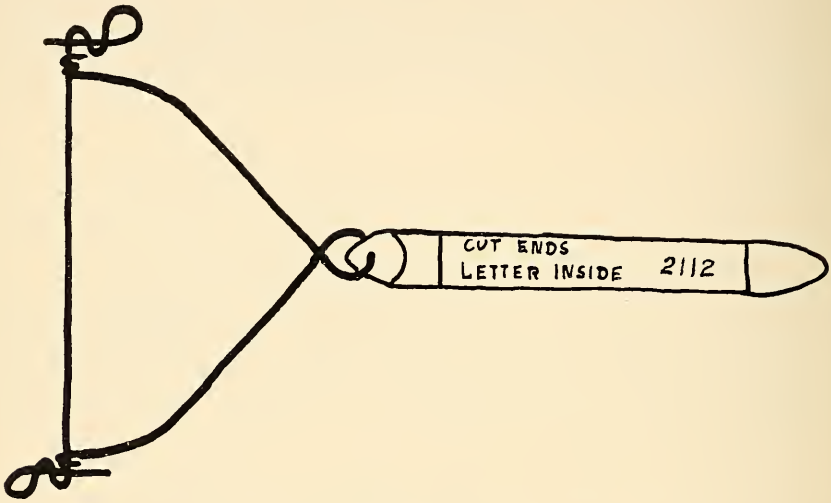

FIGURE 7. Einar Lea hydrostatic tag with wire bridle attached.

We wish to thank Mr. Einar Lea for sending us a number of his hydrostatic tags and wire bridles. This tag has been successfully used in Norway to tag cod and herring. Its principal merit is thought to be its nearly neutral buoyancy, which allows it to stream along with little strain on the fish or the attachment. The tag (Figure 7), consisting of a small transparent plastic tube with a sealed-in message, was attached to the back of the fish by a stainless steel bridle. In addition to using Lea's wire bridle, we also used monofilament nylon. The hydrostatic tags were tested on yellowtail in the aquarium and in the water tunnel.

The type D tags were applied with the aid of a hook, much like a crochet hook bent in a half circle. The hook was inserted through the back of the fish about one inch below the middle of the soft dorsal fin. The loop end of the nylon line was hooked and the hook withdrawn, pulling the tag through the muscle tissue. The capsule containing the message was passed through the loop and over its own string to form an overhand knot which secured the tag.

Aquarium Observations

Four type D streamer tags stayed in place until the fish succumbed. One was retained for three months with no sign of faults. The other three were kept under observation for about one month each and showed no defects.

Six Lea tags were used on the aquarium fish. Wire bridles were used on two fish. One came off in about four months while the other, although badly bent, lasted the duration of the experiment. The remaining four Lea tags were secured with nylon line. One came off in two months, two lasted four months, and one remained in place until the conclusion of the experiment, about five months.

Water Tunnel Test

One type D streamer tag held the duration of the test, 10 minutes at 20 to 29 miles per hour, with no faults to be found.

Five Lea tags, two attached with wire bridles and three with nylon line, were tested. One of the nylon-held marks vibrated badly and came off after 8 minutes of a 10-minute run at 20 to 29 miles per hour. The others stayed in place throughout the experiment.

Tagging at Sea

There have been 11 recoveries and two known losses from 196 type D tags used together with Petersen disks (Table 2). The time of retention ranged from 7 to 116 days. The losses occurred on fish which retained the Petersen disks for 35 and 36 days. No hydrostatic tags were used at sea.

Evaluation

The hydrostatic tag did not appear to be very satisfactory for marking yellowtail. Neither the wire bridle nor the nylon was substantial enough to secure the tags.

At the end of 1952, the type D streamer tags appeared to have done well. Neither the field trials, the aquarium observations, nor the water tunnel tests showed serious faults. However, no fish tagged in 1952 were recovered in 1953, and furthermore, there was a known 15 percent loss among the double-tagged fish. Again because other tags tested in this study have shown more merit, the use of streamer tags has been abandoned.

Tubing Tags

Four types of tubing tags have been used on yellowtail, three of which were identical to those being used by the California Department of Fish and Game to mark tunas (Wilson, 1953). The four types are:

1. No. 14 vinylite tubing with type 302, 0.032-inch diameter stainless steel wire center (tuna type E).
2. No. 14 vinylite tubing with 45-pound test braided nylon line core (tuna type F).
3. No. 14 vinylite tubing with No. 20 vinylite tubing center (tuna type G).
4. Transparent red No. 14 vinylite with 40-pound test, 0.032-inch diameter monofilament nylon center (Figure 8). The outside diameter of No. 14 tubing is approximately $\frac{1}{10}$ inch and No. 20 about 0.065 inch.

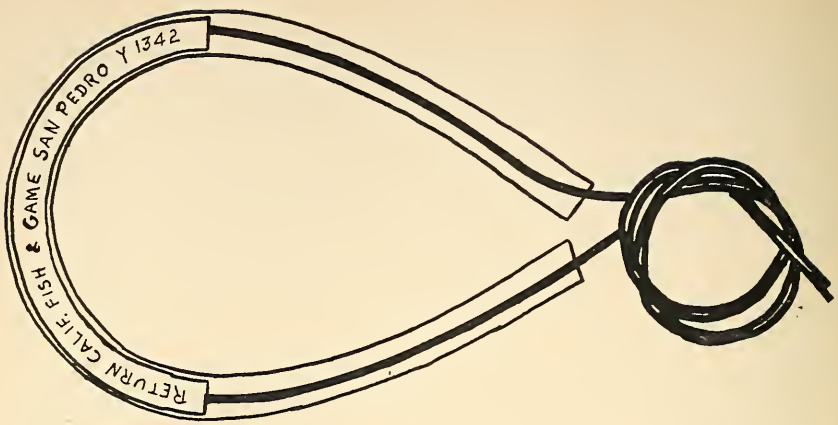

FIGURE 8. Tubing tag which is being used on yellowtail, showing the turban knot, which is rolled down to the ends of the vinylite tubing to secure the tag.

Type 4 was made as follows. The legend was inscribed on a three-inch piece of opaque white No. 20 vinylite tubing which was later drawn through an eight-inch piece of transparent tube. Lastly, 22 inches of nylon was threaded through the whole. To keep the nylon from slipping, a simple overhand knot was tied in the line and pulled into the end of the outer tubing.

The legend and number were hand-inscribed on the opaque white core with a steel quill pen, using plastic ink (California Ink Company No. 104N5A2).

The tubing tags were all attached with the aid of a stainless steel needle inserted through the back of the fish about one inch below the middle of the soft dorsal fin. The techniques for applying the type E, F, and G tuna tags were the same as described by Wilson. The vinyl-monofilament nylon tags were secured with a turban knot which was rolled down close to the ends of the tubing before cinching tight.

Aquarium Observations

No tubing tags were place on yellowtail in the aquarium.

Water Tunnel Experiment

Two tubing tags were tested and both held satisfactorily throughout the experiment.

Test on Bottom of Vessel

Twelve tubing tags were tested, six on each of the two pieces of hose. All stayed in place and none showed any defects during the 4½-month test.

Tagging at Sea

Tubing tags have been used in conjunction with Petersen disks on 1,805 fish and 605 have been used alone. Recoveries from double-tagged fish (Table 2) total 53, with no known losses. The time out has ranged from 11 to 81 days, with a mean of 39 days.

Evaluation

The staying qualities of all four types have been excellent and there is no conclusive evidence, at this stage of the investigation, that one is definitely better than another. However, in view of the desirability of narrowing the number of tags in use to only the very best, two of these types have been discontinued. The braided nylon center of the type F tag showed some tendency to fray and though none have been known to come off, it is believed that some of those returned might not have lasted much longer. The vinyl-stainless steel type E tag has also been discontinued. There may be sufficient flexure of the wire to result eventually in breakage. Secondly, tags which were partially untwisted have been returned. Finally, this tag is slower to make.

A rather serious fault occurred on several tags recently returned in that the ink had faded. The worst tag was out only 65 days. It is believed that the bad tags were from fish which spent considerable time at the surface, where the greater light intensity caused fading. That portion of the tag covered by tissue always remained in perfect condition. The problem was referred back to the California Ink Company, which found that the addition of 2 percent carbon black fortified the ink so that there was no fading when tested the equivalent of 142 days at summer sunlight. The improved formula number is 104N5A4. The assistance of the crime laboratory of the Long Beach Police Department in positive identification of the one particularly bad tag is gratefully acknowledged.

Effort has been made to have fishermen return the whole fish rather than just the tags alone and 45 specimens with the tubing tag in place have been received. This has given an excellent opportunity to observe the condition of the tags. In every case, the hole through which the tubing passed was either completely healed or was healing with no sign of soreness. It was observed that the tissue tends to grow to the vinylite and in some cases the tags adhered so tightly that removal was difficult.

MOVEMENT

At the end of February, 1954, 3,147 yellowtail had been tagged, all but one in Mexican waters, and 103 recovered (Table 1, Figure 9). Of those recaptured, 90 were taken less than 10 miles from the point of release and the remaining 13 at distances of from 20 to 240 miles (Table 3). Three fish traveled from Guadalupe Island to the mainland. The longest migration was from Guadalupe Island to Asuncion Island, a distance of 240 miles southeast in 62 days. The only recovery in California waters was a fish released at the Coronados Islands and recaptured at Santa Catalina Island. Another yellowtail from the same tagging lot moved southeast and was caught near Ensenada.

Of particular interest are some of the returns from fish which did not move. On successful trips in August and September, 1953, 1,405 yellowtail were tagged on a small bank, just a few acres in area, latitude 25° 44′ N., longitude 113° 10′ W. On the September cruise, 24 of the fish marked in August were recaptured. Commercial fishermen who

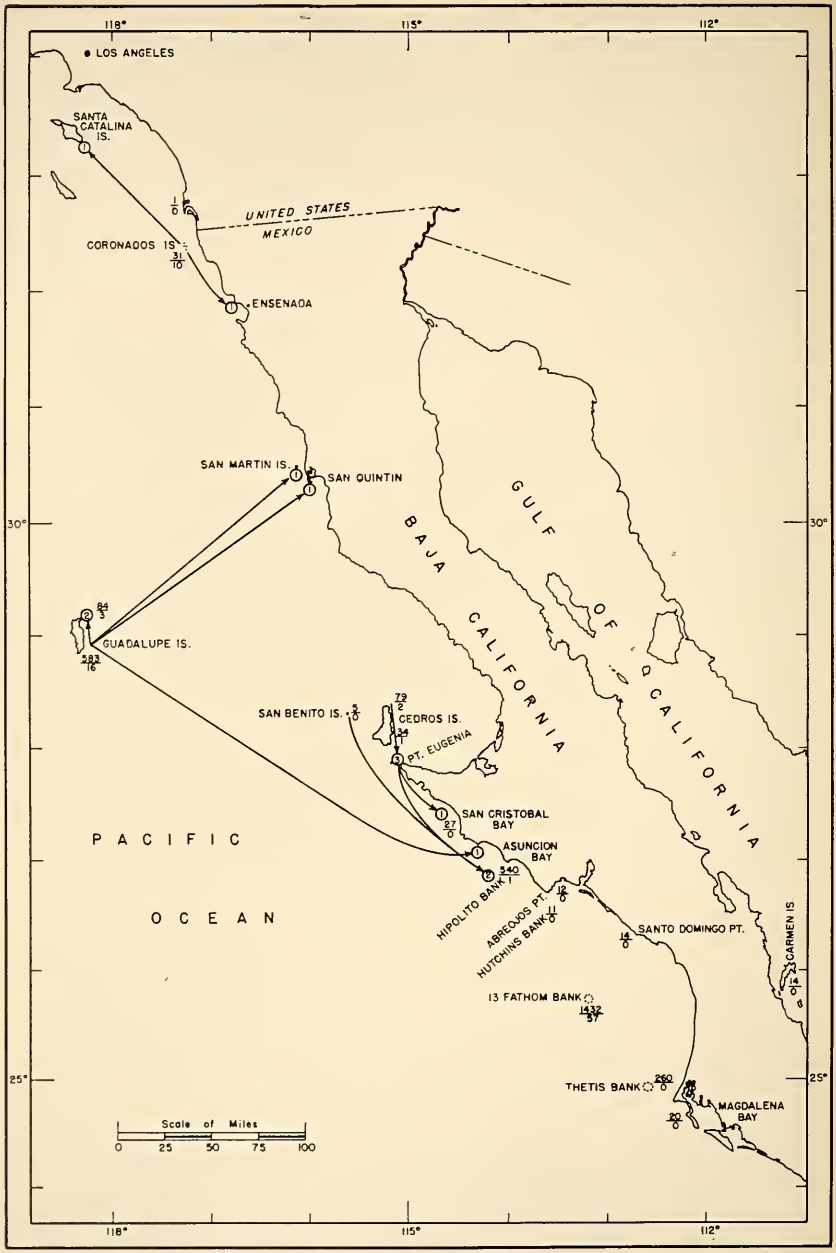

FIGURE 9. Areas in which yellowtail have been tagged and recovered. Numbers above lines indicate releases; those below lines, recoveries within a 10-mile radius. Arrows and circled figures show fish that moved more than 10 miles.

TABLE 3

Log of Tagged Yellowtail Which Moved 10 Miles or More (See Figure 9)

Date tagged	Locality of release	Locality of recapture	Direction of fish movement	Number days at liberty
1-26-52	Cedros Is., North End	Hipolito Bank	90 mi. SE.	213
1-26-52	Cedros Is., North End	Kellet Channel south of Cedros Is.	20 mi. S.	150
1-27-52	Cedros Is., North End	Kellet Channel south of Cedros Is.	20 mi. S.	129
1-27-52	Cedros Is., North End	Kellet Channel south of Cedros Is.	20 mi. S.	153
6- 2-52	San Benito Is.	Hipolito Bank	90 mi. SE.	86
6- 7-52	Guadalupe Is., South End	San Martin Is.	155 mi. NE.	172
6-11-52	Guadalupe Is., South End	San Quintin Bank	190 mi. NE.	188
4-24-53	Coronados Is.	Santa Catalina Is.	70 mi. NW.	81
4-24-53	Coronados Is.	Ensenada	45 mi. SE.	19
8- 1-53	Guadalupe Is., South End	Asuncion Is.	240 mi. SE.	62
8- 2-53	Guadalupe Is., South End	Guadalupe Is. North End	20 mi. N.	69
8- 2-53	Guadalupe Is., South End	Guadalupe Is. North End	20 mi. N.	18
9-25-53	Cedros Is., North End	San Cristobal Bay	70 mi. SE.	11

were working a school of tuna on the bank in October and November, 1953, took 40 of the yellowtail which were tagged in September. Fishermen reported seeing many more marked fish in the water. In January and February, 1954, two more visits were made to the bank. Only a few fish were taken and none bearing tags were seen or caught.

By far the greatest number of the fish marked were less than 650 mm. (25½ inches) fork length. Likewise, most of the returns (62 percent) were from these small fish, but all of the 13 fish which moved were over 650 mm.

SUMMARY

The yellowtail, *Seriola dorsalis* (Gill), is extremely important to Southern California sportsmen and is also a commercial variety of some significance. Apprehension by sportsmen over future good fishing for yellowtail resulted in the Department of Fish and Game undertaking a thorough study of the species in 1952.

A major problem was to determine whether or not the fish moved from Mexican waters, where they are most abundant, into California waters. The most direct approach to the problem lay in a tagging program. Consequently, during 1952 and 1953 considerable effort was devoted to the development of suitable tags and to marking fish at sea.

Four types of experiments were performed in developing suitable tags. These included double-tagging at sea, aquarium observations, tests in a water tunnel, and tests of tags attached to the bottom of a vessel. The tags used included: conventional Petersen disks attached by both stainless steel wire and monofilament nylon; opercular tags of several types; streamer tags, some of them hydrostatic; plastic jaw tags and plastic tubing tags similar to those used successfully on tuna.

The tubing tags and the jaw tags have been most satisfactory and their use is being continued. By the end of February, 1954, there was no evidence of tag loss from either of these types. The Petersen disks,

regardless of the means of attachment, showed serious flaws in all the experiments. This was demonstrated most forcefully by the double tagging work at sea. Of 92 recoveries from fish marked initially with Petersen disks and one of the other types, there were 66 losses of the disks. The other types of tags tested and rejected also showed losses, though not as great as for the Petersen disks.

At the end of February, 1954, 3,147 yellowtail had been tagged and released. Recoveries totaled 103, only 13 of which moved more than 10 miles from the point of release. The maximum movement recorded was 240 miles, for a fish at liberty only 62 days. The maximum time out was 213 days, by a fish which moved 90 miles. One yellowtail tagged at the Coronados Islands, just south of the International Boundary, was retaken in California waters at Santa Catalina Island. Three fish moved from Guadalupe Island, 140 miles off the coast of Baja California, to the mainland.

With the development of suitable tags, a concentrated effort is now being made to mark fish in large numbers.

REFERENCES

Alverson, D. L., and H. H. Chenoweth
1951. Experimental testing of fish tags on albacore in a water tunnel. U. S. Fish and Wildl. Serv., Comm. Fish. Rev., vol. 13, no. 8, p. 1-7.

Cable, Louella E.
1950. A cheek tag for marking fish, with semi-automatic pliers for application of tag. Jour. du Cons., vol. 16, no. 2, p. 185-191.

Calhoun, A. J.
1952. Aquarium tests of tags on striped bass. Calif. Fish and Game, vol. 39, no. 2, p. 209-218.

Calhoun, A. J., D. H. Fry, Jr., and E. P. Hughes
1951. Plastic deterioration and metal corrision in Petersen disk fish tags. Calif. Fish and Game, vol. 37, no. 3, p. 301-314.

Collyer, R. D., and P. H. Young
1952. Progress report on a study of the kelp bass, *Paralabrax clathratus*. Calif. Fish and Game, vol. 39, no. 2, p. 191-208.

Conseil Permanent International pour l'Exploration de la Mer
1953. A guide to fish marks used by members of the International Council for the Exploration of the Sea. Jour. du Cons., vol. 19, no. 2, p. 241-289.

Fry, D. H., Jr., and P. M. Roedel
1949. Tagging experiments on Pacific mackerel. Calif. Div. Fish and Game, Fish Bull. 73, 64 p.

Young, P. H., J. W. Schott, and R. D. Collyer
1953. The use of monofilament nylon for attaching Petersen disk fish tags. Calif. Fish and Game, vol. 39, no. 4, p. 445-462.

Wilson, R. C.
1953. Tuna marking, a progress report. Calif. Fish and Game, vol. 39, no. 4, p. 429-442.

PROGRESS REPORT ON THE TAGGING OF WHITE CATFISH *(ICTALURUS CATUS)* IN THE SACRAMENTO-SAN JOAQUIN DELTA[1]

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INTRODUCTION

Catfish play an important role in California sport fishing. An estimated 171,000 anglers (17 percent of all licensees) fished for them and caught almost 5,000,000 fish in 1951. Moreover, a special survey in 1948 indicated that 4.5 percent of all anglers preferred catfishing over all other types of fishing (Calhoun, 1950, 1953a).

Although catfish are found in virtually every county in the State, the fishery in the Sacramento-San Joaquin Delta area is particularly important, providing over 50 percent of the California catch.

The white catfish (*Ictalurus catus*), channel catfish (*I. punctatus*), brown bullhead (*Ameiurus nebulosus*), and black bullhead (*A. melas*) have all established breeding populations there. However, the white catfish is dominant, and the other species are taken infrequently.

Until September, 1953, both commercial fishing and sport fishing for catfish were permitted in the Delta area. A serious decline in these fisheries led to the initiation of a study of them in January, 1952.

Several thousand white catfish were tagged early in 1952 in the Delta in connection with studies of fishing pressure and migrations and the development of tagging techniques.

The first tagging experiment has thrown considerable light on the movements of white catfish in the Delta, about which nothing was known previously. It has also yielded valuable information about tagging techniques. The present report summarizes these preliminary data. Studies of fishing mortality are continuing and will be covered in a subsequent report.

METHODS

A total of 3,466 white catfish was tagged with two types of tags. The tagged fish were released at the six localities shown in Figure 1. At five of these fish were purchased directly from commercial fishermen. Tagging was done on the fishermen's wharves, using their live cars, tables, and other facilities. The fish tagged at the Antioch locality were captured by project personnel, during the commercial closed season.

When large numbers of catfish are concentrated, some individuals become punctured or cut by the spines of others. All such injured fish

[1] Submitted for publication March, 1954. This work was performed as part of Dingell-Johnson Project California F-2-R, "A Study of the Catfish Fishery of California," supported by Federal Aid to Fish Restoration funds.

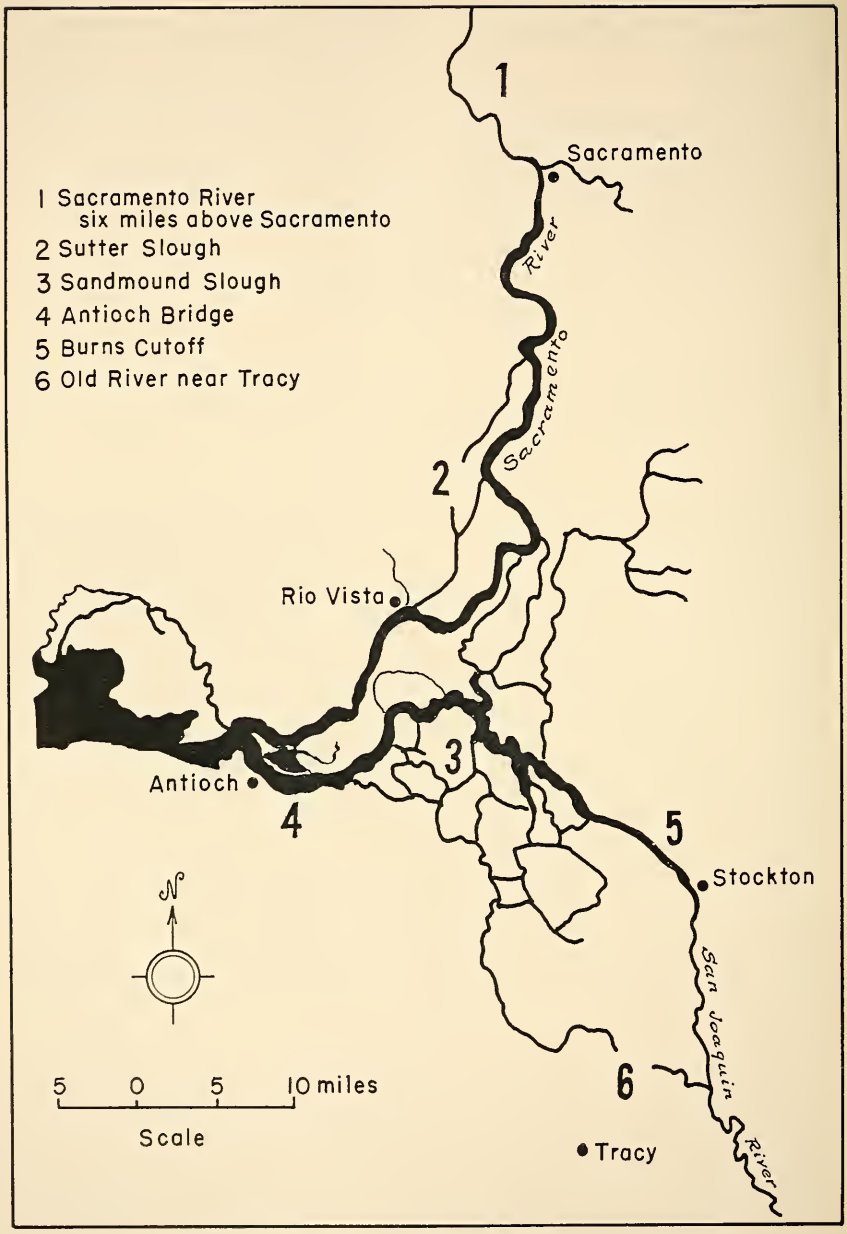

FIGURE 1. The six localities at which catfish were released.

were discarded, and only fish in perfect condition were tagged. Although catfish can be kept out of water for long periods in cold weather without harm, an effort was made to keep the fish out of the water for a short while only. In no case were fish observed to be in distress when returned to the water, or later found dead.

Fork length measurements to the nearest tenth of an inch were made on all tagged fish. Tagging was done between January 15 and June 10, 1952.

Two types of tags were used in the study: an opercular strap tag, and a disk tag attached with tantalum wire. Earlier preliminary tagging with standard Petersen disk tags had shown them to be totally unsuitable for white catfish because of rapid shedding. The strap tag

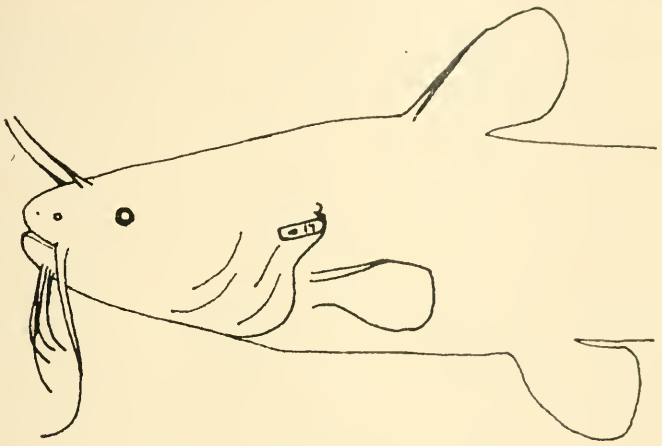

FIGURE 2. The opercular strap tag shown in place. The tag is anchored securely by piercing the bony opercular plate.

(Figure 2) was supplied by the National Band and Tag Company of Newport, Kentucky. It is a self-piercing monel metal tag, size No. 1, style 1005, applied with special pliers. As used on white catfish, the clasp of the tag pierced the bony opercular plate, anchoring the tag securely.

The other type of tag used has been called the disk-dangler tag (Calhoun, 1953b). It is a variation of the Atkins type tag (Rounsefell and Kask, 1945), and consists of a cellulose nitrate disk, one-half inch in diameter and 0.040 inch thick, attached with 0.020-inch tantalum wire. The tag was attached to the fish's body beneath the dorsal fin with two strands of wire, as shown in Figure 3.

It was found that a small, viselike clamp holding two hypodermic needles of appropriate size provides a convenient method of getting the wires through the fish's body. The clamp is shown in Figure 4. The needles are put in place and pushed through the body in one motion. The tag wires are then inserted into the hollow needles and the clamp pulled outward. This leaves the tag in place with the wires through the fish's body. These tags were put on with one wire anterior to, and one wire posterior to, the origin of the dorsal spine. A metal spacing strap placed between the protruding wires keeps them from pulling

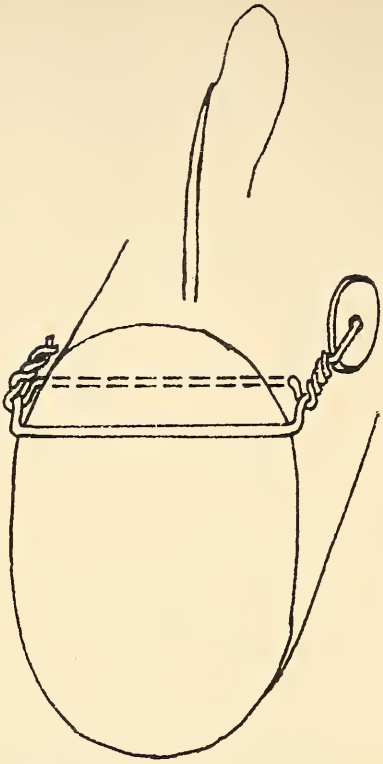

FIGURE 3. Disk-dangler tag shown in place. The exposed wire and tag are bent backward so as not to catch on nets, weeds, or other obstructions.

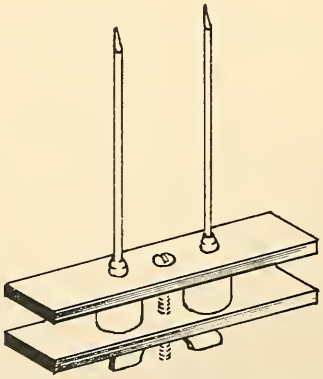

FIGURE 4. The clamp holding two hypodermic needles used in the application of the disk-dangler tag.

together and tearing the flesh when they are twisted together. The tagging process is completed by cutting off the excess wire on the twisted end, and bending back the exposed wire and tag so that they will not tend to catch on weeds, nets, or other obstructions.

It should be mentioned that the clamp holding the hypodermic needles, although suitable for tagging catfish, is not satisfactory for scaled fishes. The needles are deflected by the scales, and do not remain parallel. As a result they may emerge on the opposite side at the same point, or perhaps an inch apart.

Original plans called for the application of 480 opercular strap tags and 120 disk-dangler tags at each of the six locations. Deviation from this number was due primarily to missing tags and unavailability of fish.

In order to insure as complete a return as possible, several methods of stimulating interest in the return of the tags were used:

(1) Posters (Figure 5) advising the public of the tagging program were distributed widely at boat liveries and fishing spots throughout the area.
(2) Press interviews and releases were utilized as much as possible to inform the public of the tagging program.
(3) Talks were given to sportsmen's groups.
(4) Commendation cards (see Figure 5) were sent to persons returning catfish tags.
(5) Every person returning a catfish tag had his name entered in drawings sponsored by the Foothill Sportsmen's Club of Oakland. An annual first prize of $100 has been given, along with many other attractive merchandise prizes. Wide newspaper publicity was given to these drawings.

RESULTS

The results obtained in the first year of this tagging study are summarized in Table 1. The rate of return from the different tagging locations varies considerably. Considering disk-dangler tags only, the return from Sutter Slough was lightest, with only 2.5 percent. The greatest return (22.5 percent) was from Old River. The total return from all disk-dangler tags was 16.3 percent.

The tagged catfish ranged in size from 5.6 to 17.6 inches fork length. The mean length was 8.52 inches. Catfish for which tags were returned ranged from 6.4 to 13.9 inches, with a mean length of 8.54 inches. The difference is not statistically significant at the 1 percent level.

Suitability of Tags

The most striking result of the study thus far has been the demonstration of the superiority of the disk-dangler tag over the opercular strap tag. A return of 16.3 percent was obtained from the disk-danglers over a period of one year, while over the same period of time and under the same conditions only 2.6 percent of the strap tags were returned.

The writer is confident that this great difference in rate of return is not due entirely to the ability of the tags to remain on the fish, since experiments conducted at Steinhart Aquarium and Central Valleys

TAGGED
CATFISH
Have been RELEASED in this
AREA
RETURN TAGS TO
California Department of Fish and Game
FERRY BUILDING SAN FRANCISCO, CALIF.
BE SURE TO INCLUDE THIS INFORMATION
1. Your Name and Address.
2. Date the catfish was taken.
3. Place. Be as exact as possible.
4. Length of the catfish.
Measure from front of head to tip of tail.
Be as exact as possible.
This is to
CERTIFY THAT
OFFICIAL COMMENDATION CARDS
are sent to fishermen who return tags with the necessary information regarding their recovery. A brief history of the catfish is furnished with each card.
YOUR TAGS AND YOUR INFORMATION
are needed to help the Department of Fish and Game maintain the supply of catfish.
DIFFERENT TYPES OF TAGS
Other types of tags may be used or they may be on different parts of the fish.
RETURN ALL TAGS
CALIFORNIA DEPARTMENT OF FISH AND GAME

FIGURE 5. Poster used to advise the public of the tagging program.

State Fish Hatchery demonstrated that both types of tags remain in place satisfactorily for a year. In the experiment at the hatchery 100 white catfish were tagged with strap tags, and half of these were also tagged with disk-dangler tags. The fish were held in a weed-choked pond of one-third acre, and checked at regular intervals for a period of one year. At the end of this time none of the tags had fallen off and few were loose. However, the strap tags had all become hidden under a covering of opaque mucus, making them difficult to see. Anglers do not tend to look closely at their catfish after catching them, and it is believed that most of the opercular strap tags went unnoticed.

In the few cases in which the writer has had the opportunity to observe tagged catfish after capture, the disk-dangler tags appeared to be in good condition. Not infrequently the exposed wire on the side of the fish opposite the disk becomes buried in the flesh, leaving no scar. In no case has wire corrosion or plastic deterioration been noted.

Migration

The movement of tagged white catfish from the point of tagging was sporadic and without apparent direction. In general, the picture is one of gradual diffusion from the point of tagging. For each fish that makes a considerable movement in one direction, there is usually another one that made an equally long movement in the opposite direction at about the same time. Only 20 of 173 tags returned were from fish captured near their point of release. Eighty-five fish traveled upstream from the point of release, averaging 9.8 miles; 53 fish that were captured downstream from the point of release traveled an average distance of 8.6 miles. Movements of 15 fish could not be determined.

The fact that white catfish are capable of moving quite rapidly was demonstrated by the capture of one individual 25 miles from the tagging locality only eight days after being tagged. The longest movement of a tagged fish was 55 miles, accomplished in slightly over two months. Individual movements of catfish from one point of tagging are shown in Figure 6.

Commercial fishermen in the area have thought for a number of years that catfish leave the lower reaches of the Sacramento and San Joaquin rivers during the winter months and congregate in quiet, warmer sloughs throughout the Delta. They chose their fishing areas accordingly. Sampling activities of the writer have also indicated such a

TABLE 1

Data on Tags Applied and Tags Returned During the First Year

Tagging location	Tags put on			Tags returned		
	Strap	Disk-dangler	Total	Strap	Disk-dangler	Total
Antioch Bridge	480	124	601	7 (1.5%)	27 (21.8%)	34 (5.6%)
Old River near Tracy	480	120	600	20 (4.2%)	27 (22.5%)	47 (7.8%)
Burns Cutoff	477	118	595	21 (4.4%)	27 (22.9%)	48 (8.1%)
Sandmound Slough	479	None	479	15 (3.1%)	None	15 (3.1%)
Sutter Slough	479	119	598	9 (1.9%)	3 (2.5%)	12 (2.0%)
Sacramento River six miles above Sacramento	470	120	590	3 (0.6%)	14 (11.7%)	17 (2.9%)
Totals	2,865	601	3,466	75 (2.6%)	98 (16.3%)	173 (5.0%)

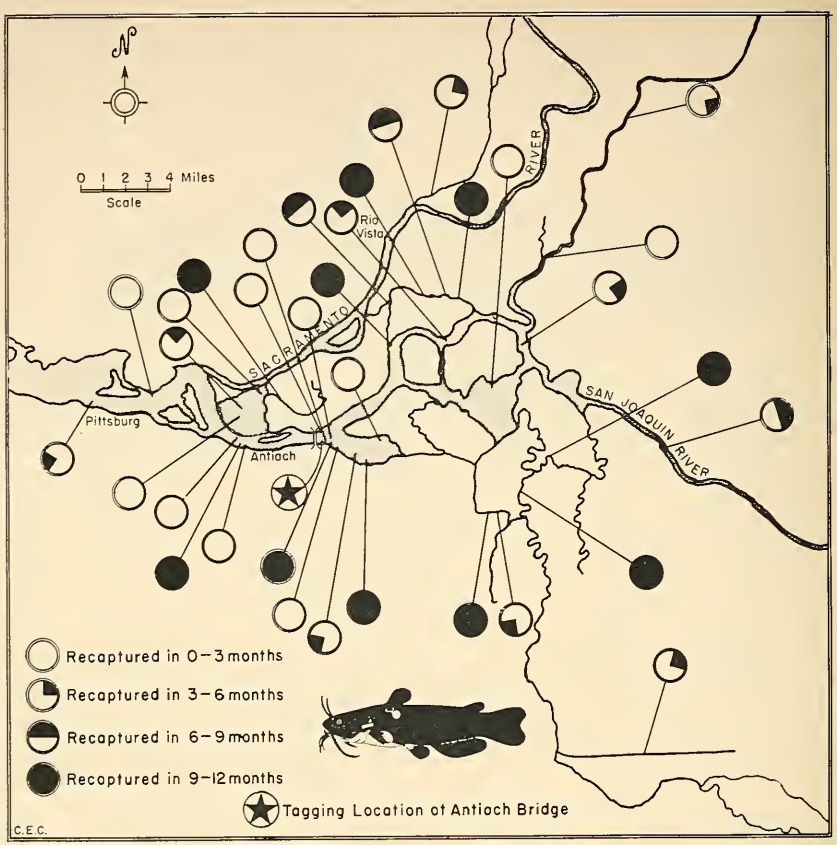

FIGURE 6. Tag recoveries made from fish tagged at the Antioch Bridge locality. The results are typical of those obtained from other localities.

seasonal change in distribution. It will be necessary to tag larger numbers of catfish with suitable tags for this to become evident from tag returns.

ACKNOWLEDGMENTS

Acknowledgments are due Alex Calhoun, under whose guidance the tagging study was conducted. I am indebted to the California Department of Fish and Game employees who assisted in the capture and tagging of catfish, particularly Vincent Catania. I also wish to thank the Foothill Sportsmen's Club of Oakland for generously sponsoring prize drawings to stimulate interest in the tagging program.

SUMMARY

During the early part of 1952, 3,466 white catfish were tagged at six different localities in the Sacramento-San Joaquin Delta area of California.

Two different types of tags were used. The return of disk-dangler tags was approximately six times that of opercular strap tags. It is believed that the principal reason for this difference lies in the fact that the strap tag is difficult to see, and is not noticed by anglers.

Migration or movement of the catfish from the point of tagging was quite sporadic and without apparent direction. The fish are capable of covering considerable distances in rather short periods of time.

LITERATURE CITED

Calhoun, A. J.

1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish and Game, vol. 36, no. 3, p. 177-234.

1953a. State-wide California angling estimates for 1951. Calif. Fish and Game, vol. 39, no. 1, p. 103-113.

1953b. Aquarium tests of tags on striped bass. Calif. Fish and Game, vol. 39, no. 2, p. 209-218.

Rounsefell, G. A., and J. L. Kask

1945. How to mark fish. Amer. Fish. Soc., Trans., vol. 73, p. 320-363.

FIELD TESTS OF STAINLESS STEEL AND TANTALUM WIRE WITH DISK TAGS ON STRIPED BASS[1]

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California Department of Fish and Game

Recent fish tagging programs have indicated that some of the materials commonly used for disk tags are inadequate. Metals such as monel, nickel, and silver have proven unsatisfactory on marine and anadromous fishes (Calhoun, Fry, and Hughes, 1951).

A field tagging experiment with striped bass (*Roccus saxatilis*) was undertaken in 1951 to evaluate tantalum and stainless steel as possible substitutes. Petersen type cellulose nitrate disks one-half inch in diameter and 0.045 inch thick were used with three types of wire, all 0.032 inch in diameter. Tantalum was used with disks having serial numbers ending in 1, 4, and 7; type 302 medium soft temper stainless steel with numbers ending in 2, 5 and 8; and type 302 passivated dead

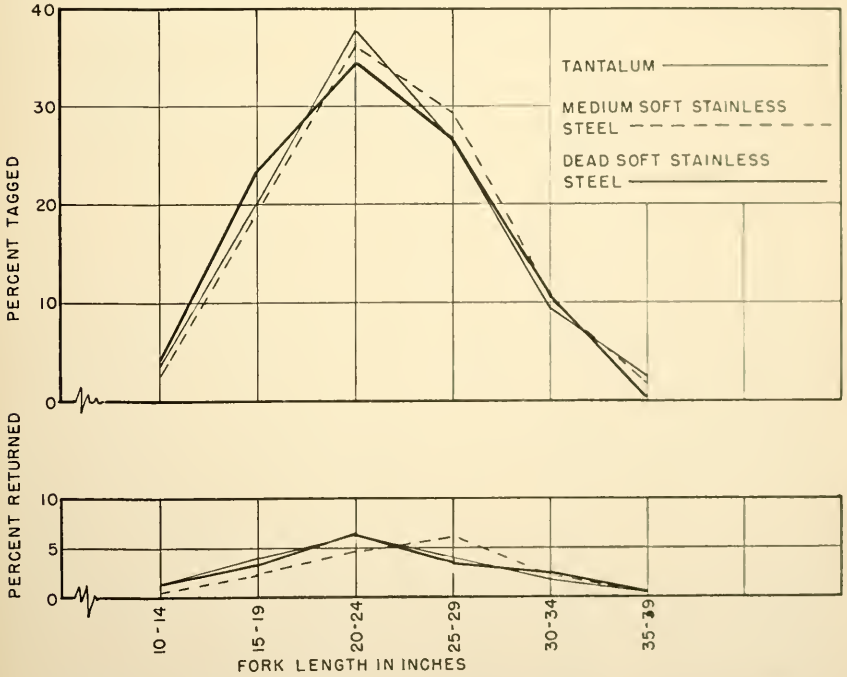

FIGURE 1. Length frequencies of striped bass togged (upper) and returned (lower) for each of three types of wire.

[1] Submitted for publication March, 1954.

TABLE 1

Comparison of Returns of Tags With Tantalum and Stainless Steel Wires

Type of wire	Number tagged	Returns		Days at large					
				0-365		366-730		Over 730	
		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Tantalum	363	63	17.36	49	13.5	12	3.3	2	.55
Dead soft temper stainless steel	483	84	17.39	70	14.5	13	2.6	1	.21
Medium soft temper stainless steel	365	57	15.62	45	12.3	10	2.7	2	.55
Totals	1,211	204	16.85	164	13.5	35	2.9	5	0.4

soft temper stainless steel with those ending in 0, 3, 6, and 9. The fish were all tagged on the caudal peduncle (Calhoun, 1953; Figure 2).

A total of 1,211 striped bass ranging from 10 to 39 inches in fork length was caught with gill nets (Calhoun, 1952) and tagged in the above manner during April and May of 1951. The length frequencies of the fish tagged are shown in Figure 1.

Two hundred and four tags (16.85 percent) were returned by February 1, 1954, two years and nine months after tagging began. The elapsed time between tagging and recovery ranged from 0 to 1,005 days, with a mean of 225 days for the combined returns.

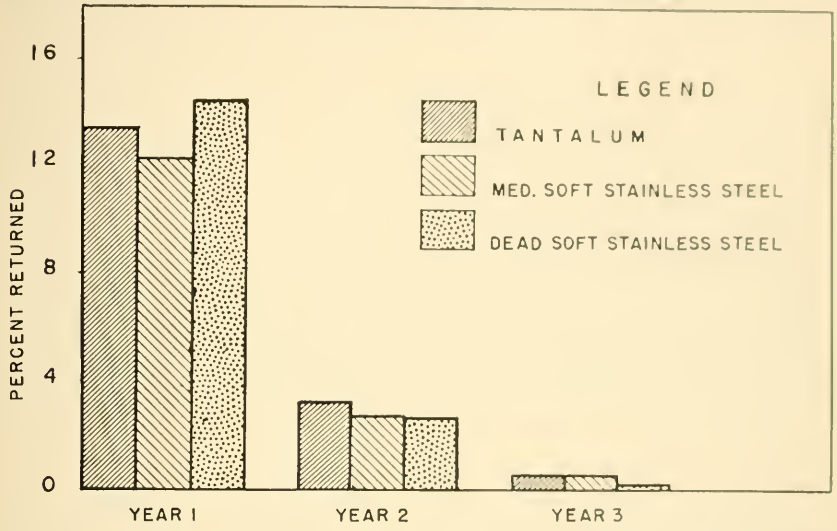

FIGURE 2. Comparative returns of three types of wire used for tagging striped bass. Returns in the third year are for the first nine months of that year only.

The total percentage returned and the pattern of elapsed time between tagging and recapture were essentially the same for the three metals within each of the three years following tagging (see Table 1 and Figure 2). The general similarity of the returns of the three types of tags throughout the entire recovery period is shown by Figure 3.[2]

An analysis of variance failed to show any statistically significant difference in the returns of the three types of wires, using the mean number of days at large as the criterion for distinction. The mean number of days at large and standard deviation for each type of wire are given in Table 2.

Figure 1 (lower) reveals that a slightly smaller percentage of striped bass tagged with medium soft stainless steel wire were returned in the shorter length classes, compared with tantalum and dead soft stainless steel, while the converse is true for the longer length classes. Statistical

[2] After the manuscript had been submitted for publication 4 wires which had been out for considerable time were returned: 2 dead soft steel wires out for 886 and 1,145 days, and 2 tantalum wires for 1,106 and 1,123 days.

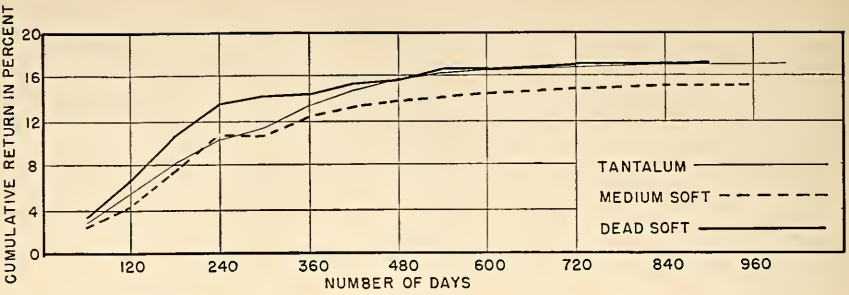

FIGURE 3. Cumulative returns of tantalum and stainless steel wires.

procedures showed significant differences between the returns (at the 5 percent level) for the shorter length classes, whereas the returns for the longer length classes approached, but did not reach, the significant level.

A plausible explanation for these differences is that the medium soft stainless steel is considerably less flexible than the other two metals and is therefore more apt to cut its way through the soft flesh of the smaller fish. Further, it is more difficult to tie a knot providing the desired amount of slack in the medium soft stainless steel, especially when tagging small fish. With repeated bending tantalum and dead soft stainless steel break much more readily than does medium soft stainless steel. This may explain the smaller number of returns for the larger fish in the case of the former.

TABLE 2

Mean Number of Days at Large and Standard Deviation for Tantalum and Stainless Steel Wire

Type of wire	Number returned	Mean number of days at large	Standard deviation
Tantalum	63	246	±189.5
Dead soft temper stainless steel	84	201	±171.1
Medium soft temper stainless steel	57	236	±194.4

It is of interest to compare the retention period of these tags with those used in earlier experiments. Merriman (1941) tagged 2,573 striped bass with modified Scottish plaice tags located beneath the dorsal fin, attaching them by means of nickel pins. The total return was 21 percent, with a maximum elapsed time of 608 days between tagging and recovery.

Clark (1936) reported a recovery of 10 percent for 1,544 small striped bass tagged beneath the dorsal fin with disks and nickel pins. The recovery period ranged from 4 to 477 days.

Morgan and Gerlach (1950), tagging striped bass in Oregon with Petersen disks and nickel pins, reported a 13 percent return with a maximum elapsed time of 128 days.

In exploratory field tagging experiments with striped bass in California prior to 1951, in which monel and nickel wire with disk tags located under the dorsal fin was used, few if any tags were returned after a year and a half.

In the present experiment, tags were returned after 1,005 days, indicating a considerable improvement in retention.

The objective of these tagging studies was to develop a tag which would remain on striped bass for at least a year, to permit an evalnation of fishing mortality. It appears that this has been approached, if not achieved, by the tags used in this experiment. Since tantalum and stainless steel gave similar results, the latter is obviously to be preferred because of its lower cost.

ACKNOWLEDGMENTS

The knowledge and skill of Vincent Catania were largely responsible for the success of this project. He netted the fish which were tagged, while William Johnson and David E. Pelgen did the tagging and kept the field records.

The outstanding publicity program conducted by the San Francisco Striped Bass Club created widespread interest in the tagging study. A yearly prize of $100 and other lesser awards presented by this organization at periodic drawings greatly encouraged the return of tags to the Department of Fish and Game. A similar program recently inaugurated by the Bethel Island Rod and Gun Club is also gratefully acknowledged.

SUMMARY

In 1951, 1,211 striped bass were tagged on the caudal peduncle with cellulose nitrate disks and three types of wire: tantalum, passivated dead soft stainless steel type 302, and medium soft stainless steel type 302. There were 204 returns (16.85 percent) by February 1, 1954. The elapsed time between tagging and recapture ranged from 0 to 1,005 days. There were no significant differences in the three metals, in either the total proportion returned or the elapsed time between tagging and recapture.

A small but significant difference was noted between the returns as related to the length of the fish. Comparatively fewer small fish were returned with medium soft stainless steel than with tantalum or dead soft stainless steel.

The recovery period in this experiment was significantly longer than in earlier studies, in which nickel and other metals were used with tags beneath the dorsal fin.

REFERENCES

Calhoun, A. J.
1952. Annual migrations of California striped bass. Calif. Fish and Game, vol. 38, no. 3, p. 391-403.
1953. Aquarium tests of tags on striped bass. Calif. Fish and Game, vol. 39, no. 2, p. 209-218.

Calhoun, A. J., D. H. Fry, and E. P. Hughes
1951. Plastic deterioration and metal corrosion in Petersen disk fish tags. Calif. Fish and Game, vol. 37, no. 3, p. 301-314.

Clark, G. H.
1936. A second report on striped bass tagging. Calif. Fish and Game, vol. 22, no. 4, p. 272-283.

Merriman, Daniel
1941. Studies on the striped bass (*Roccus saxatilis*) of the Atlantic Coast. U. S. Fish and Wildl. Serv., Fishery Bull., vol. 50, no. 35, p. 1-77.

Morgan, Alfred R., and Arthur R. Gerlach
1950. Striped bass studies in Coos Bay, Oregon. Ore. Fish. Comm., Contrib. No. 14, 31 p.

A SURVEY OF THE COAST CUTTHROAT TROUT, *SALMO CLARKI CLARKI* RICHARDSON, IN CALIFORNIA[1]

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INTRODUCTION

Although of restricted distribution and one of the least known trout of California, the Coast Cutthroat Trout, *Salmo clarki clarki* Richardson, occupies an environmental niche that has not yet been filled by any other fish. Probably because of its relative unimportance numerically, no general scientific studies have previously been made of this fish in California. Sumner (1948) has conducted intensive research into the life history of the coast cutthroat in Oregon. Very little has been published concerning it in the State of Washington, but Dymond (1928, 1932), Haig-Brown (1947), and Neave (1949), have contributed considerably to the knowledge of the fish in British Columbia.

With an allegedly declining population of coast cutthroat in California there is a need for definite information on this subspecies. The present paper is based on a study made during 1951 to determine its general distribution and status in the State, as the first step in the search for information on which to base its management.

DISTRIBUTION IN CALIFORNIA

In California the coast cutthroat is restricted mainly to the area bounded by the Eel River, the Oregon state boundary line, the Pacific Ocean, and the summit of the Coast Range (Figure 1). It has also been reported from tributaries of the Rogue River in California's Siskiyou County. Murphy and DeWitt (1951) established what appears to be the first definitive record of the cutthroat in the Eel River system. In that river system cutthroat have been found only in the main river, in tidewater, and in six small tributaries, all within 10 miles of the ocean.

From Eel River northward the distribution extends gradually farther inland. In the Klamath River drainage cutthroat have been taken about 20 miles inland. In the Smith River system they are common even in the headwaters, some 50 to 60 miles from the ocean.

The Smith River system is the most important coast cutthroat area. Virtually all sections of the river and its tributaries are known to contain or are reported to contain cutthroat (see Table 1).

[1] Submitted for publication January, 1954.

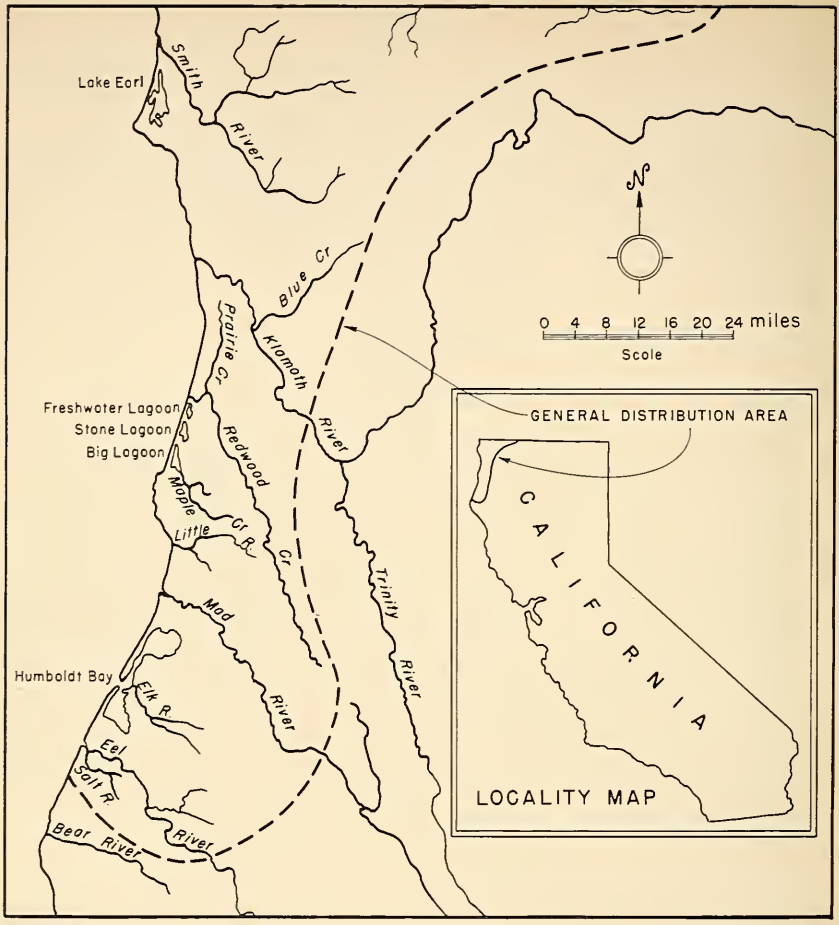

FIGURE 1. Map showing the range of the coast cutthroat trout in California.

DISTINCTIVE FEATURES OF THE COAST CUTTHROAT

The coast cutthroat in California is a slender fish (Figure 2), generally not as deep-bodied nor as large as its cousin, the Steelhead Rainbow Trout (*Salmo gairdneri gairdneri*), in the same waters. Few specimens weighing more than three or four pounds are taken, while the sea-going rainbow frequently exceeds 10 pounds.

The cutthroat may generally be distinguished from steelhead and other trout of the rainbow series by the presence of hyoid teeth and reddish or orange dashes on the throat, as well as by differences in body coloration.

The presence of hyoid teeth is one of the most reliable characters for distinguishing cutthroat from trout of the rainbow series. Rainbows lack these teeth. However, not all cutthroats possess them, as shown

TABLE 1

Waters Containing Coast Cutthroat Trout in California [1]

Eel River—C
- Salt River
  - Russ Creek—C
  - Reas Creek—C
  - Francis Creek—C
  - Williams Creek—C
- Strongs Creek—C
- Barber Creek—C

Elk River—C
Mad River—C
- Mill Creek—C
- Warren Creek—C
- Lindsay Creek—C
- North Fork Mad River—C

Widow White Creek—R
Clam Beach Lagoons—C
Little River—C
Luffenholtz Creek—R
McNeil Creek—C
Patrick Creek—R
Big Lagoon—C
- Maple Creek—C

Stone Lagoon—C
- McDonald Creek—C

Freshwater Lagoon—C
Redwood Creek—C
- Prairie Creek—C
  - Lost Man Creek—C

Klamath River—C
- Panther Creek—R
- Hunter Creek—C
- Turwar Creek—R
- Ah Pah Creek—C
- Tectah Creek—C

Wilson Creek—R
Lake Earl—R
Smith River—C
- Rowdy Creek—R
- Little Mill Creek—R
- Mill Creek—C
- South Fork Smith River—C
  - Goose Creek—C
  - Hurdygurdy Creek—R
  - Jones Creek—C
  - Fall Creek—C
- Middle Fork Smith River—R
  - Patrick Creek—R
  - Jones Creek—C
  - Monkey Creek—C
  - Siskiyou Fork—R
- North Fork Smith River—R
  - Diamond Creek—R

South Fork Winchuck River—R

[1] C = Cutthroat trout collected during course of study; R = Cutthroat trout reported but not collected during study.

FIGURE 2. Three coast cutthroat trout from Monkey Creek, tributary to the Middle Fork of Smith River, Del Norte County, California. Largest specimen about 12½ inches long, fork length. *Photograph by John W. Westgate, August, 1951.*

by Dymond (1928) and others; and, as Miller (1950) points out, all trout having hyoid teeth are not pure cutthroat, for hybrids may have as many as six teeth.

Generally, the hyoid teeth are arranged in two rows meeting at either end, to form a boat-shaped pattern. Frequently, several more are located inside the two outer rows. The teeth are located on the basibranchial bones approximately between the first and second gill arches. They are deciduous and thus very easily scraped away or broken. The teeth are fang-shaped and usually point toward the back of the throat. In large specimens they may be seen easily with the naked eye or felt with the finger; in small individuals (two to three inches long) they may be readily located with the use of a microscope.

Seventy-nine specimens from nearly all sections of the range were examined. In 73 of these fish the number of hyoid teeth varied from 1 to 34. Most of the counts fell between three and nine, and the average number was 8.8. The counts were made with a binocular microscope under a bright blue light, using a very fine dissecting needle. The usual procedure, which required considerable care, was to count all teeth visible without disturbing the mucus covering over the tooth area. Then, after carefully removing the mucus, a second count was made. Often several teeth would be hidden by the mucus, giving an initial count lower than the actual number present. On occasion, however, during the removal of the mucus one or more teeth were lost, giving a higher initial count.

Nearly all cutthroat observed in this study possessed red, orange, or red-orange throat dashes. Several small specimens under four inches in length and one large tidewater fish did not have the dash. Dymond (1928) and Sumner (1948) also noted that at certain stages cutthroat may not have the red dash. A number of specimens, from Tectah Creek especially, had the general appearance of cutthroat, but instead of the red or orange dash possessed faint yellow or bronze streaks. These fish possessed other somewhat intermediate features and may have been cutthroat-rainbow hybrids.

There was great variation in coloration and an even greater variation in spotting. It was impossible to select any one specimen as a truly "typical" coast cutthroat which would represent all others in its general appearance.

Fish taken in or near tidewater areas were the most uniform in appearance. The most marked diversity occurred among those in small streams and in headwater areas.

The tidewater fish examined were usually more faintly spotted than specimens from other waters. They were often silvery in coloration. Among the upstream fish the spotting varied from profuse to scarce, and the spots ranged from rounded to irregular in shape. Even fish from the same part of a single stream sometimes differed strikingly in the spotting.

General coloration ranged from washed-out brown to brilliant blues and greens. Every specimen examined from the Eel River tributaries was a dirty-white color. In these the jaw dash was a faded orange or red-orange and the spotting on the back was indistinct. A number of Prairie Creek specimens possessed the same general features.

The most strikingly colored fish were those from several very small, clear creeks flowing directly into the ocean. These, as well as many from other areas, characteristically displayed predominantly red-orange pectoral, ventral, and anal fins. The bases of these fins were ordinarily greyish-white and the free margins milky-white. In other specimens, the pectoral fins were yellow, the ventrals red-orange, and the anals yellow and orange. The characteristic pattern among fish taken from murky waters was grey-white pectoral, ventral, and anal fins.

Diagonal rows of scales were counted along the second row above the lateral line within the standard length (measured from tip of snout to base of the center caudal fin rays) on 78 of the cutthroat examined. The mean count was 151.7. The range of the counts was 122 to 188. Approximately 80 percent of the values fell between 137 and 165. In referring to the coast form, Snyder (1908) stated that the scales in the lateral series of *Salmo clarki* vary generally from 140 to 170. In a later paper (Snyder, 1940), he listed the range as 160 to 200.

Pyloric caecum counts were made on 71 of the specimens examined. The mean number was 40.3. The extreme range of the counts was from 23 to 60; however, the majority were between 30 and 50. These values vary rather widely, thus extending the range given by Miller (1950), who gives the limits as 27 to 45.

LIFE HISTORY NOTES

In the fall and winter fresh sea-run cutthroat are taken in varying numbers from Redwood Creek and the Mad, Klamath, and Smith Rivers. Most of the fish are caught in September or October, usually after the first substantial rain. Only a few are taken from Mad River, with larger numbers from Redwood Creek and tributaries, and the Klamath. Very good catches of apparently sea-run fish are made in tidewater areas of the Smith, especially in the fall, winter, and early spring, but occasionally also in the summer.

Female cutthroat containing ripe or nearly ripe eggs have been taken from September to April. Spawning thus evidently occurs over a relatively long period. Small, newly emerged fry have been seen from March to June. In British Columbia, according to Dymond (1932), spawning occurs from February to May in the small streams. Dimick and Merryfield (1945) say that the migratory phase spawns in January and February in Oregon.

During the summer and early fall the cutthroat populations in coastal California streams consist ordinarily of fish of the year class 1 to and including mature fish that have spawned but have never gone to the ocean, plus a few sea-run individuals landlocked by receding water levels after spawning.

Log jams and natural falls block many streams at different points, preventing, at least in part, the migration of steelhead and salmon into the waters above. Almost pure or predominantly cutthroat populations exist in the sections above these barriers on a number of streams, while almost none are found below the barriers in the summer and early fall. Some of the fish above barriers are sexually mature although relatively small, usually under 10 inches in length.

Fish-of-the-year were taken only in the very smallest tributaries, usually in those with summer flows less than one cubic foot per second. Most of the cutthroat brood streams examined were too small to be named. Large cutthroat occur in many streams throughout the year; life histories of such individuals vary considerably.

In September of 1951 a 779-foot section of Prairie Creek was cut off by diverting the flow into an artificial channel. The cut-off section was seined, treated with rotenone, and reseined. The fish population collected was composed of sculpins (*Cottus* sp.) (72.7 percent), silver salmon (*Oncorhynchus kisutch*) (15.0 percent), steelhead (*Salmo gairdneri gairdneri*) (8.7 percent), stickleback (*Gasterosteus aculeatus*) (2.2 percent), cutthroat trout (*Salmo clarki clarki*) (0.9 percent), and king salmon (*Oncorhynchus tshawytscha*) (0.3 percent). The total number of fish of all kinds taken was 674. Scale readings of the nine cutthroat collected indicated that none had undergone any ocean or tidal growth. The ages of these fish varied from two to six years (Table 2). No cutthroat-of-the-year were found in the cut-off section.

TABLE 2

Length, Age, and Residence of Coast Cutthroat Trout From Prairie Creek Cutoff [1]

Fork length in inches	Number of stream annuli [2]	Calculated length at each annulus						Ocean or tidal growth
		1	2	3	4	5	6	
15.0	6	3.2	4.8	6.1	8.2	11.1 [3]	13.4 [3]	None
10.1	4	3.2	4.9	7.5	8.9	----	----	None
8.6	3	2.4	4.3	6.0	----	----	----	None
8.1	3	2.8	4.6	7.0	----	----	----	None
6.1	2	2.0	4.4	----	----	----	----	None
5.7	2	2.8	4.7	----	----	----	----	None
5.3	2	3.1	4.3	----	----	----	----	None
5.4	2	2.0	4.1	----	----	----	----	None
4.7	2	1.7	3.8	----	----	----	----	None

[1] Determinations by F. H. Sumner of the Oregon Game Commission.
[2] Not counting edge where annulus is partly formed in some samples.
[3] Spawning check.

SUMMARY

In California the Coast Cutthroat Trout (*Salmo clarki clarki*) is restricted mainly to the area bounded by the Eel River, the Oregon state boundary line, the Pacific Ocean, and the summit of the Coast Range. The Smith River system is the most important cutthroat area.

The cutthroat may generally be distinguished from steelhead and other trout of the rainbow series by the presence of hyoid teeth and reddish or orange dashes on the throat, as well as by differences in body coloration.

This form is extremely variable in California. Pyloric caecum counts range from 23 to 60; scale rows along the lateral line vary from 122 to 188; hyoid teeth vary from 1 to 34.

Fresh sea-run cutthroat are taken in varying numbers from the main streams within their California range during the fall and winter.

There are indications that some coast cutthroat do not migrate to sea and constitute resident, breeding populations.

Fish-of-the-year were found only in the very smallest tributary streams, usually those with summer flows less than one cubic foot per second.

ACKNOWLEDGMENTS

Thanks are extended to Leo Shapovalov of the California Department of Fish and Game and to Dr. Donald E. Wohlschlag of Stanford University for reading the manuscript critically and offering valuable suggestions during the course of study. John W. Westgate assisted the writer in making many trout collections.

LITERATURE CITED

Dimick, R. E., and Fred Merryfield
1945. The fishes of the Willamette River system in relation to pollution. Oregon St. Coll., Eng. Expt. Sta., Bull., no. 20, 58 p.

Dymond, J. R.
1928. The trout of British Columbia. Amer. Fish. Soc., Trans., vol. 58, p. 71-77.
1932. The trout and other game fishes of British Columbia. Ottawa, Dept. Fisheries, 51 p.

Haig-Brown, Roderick L.
1947. The western angler—an account of Pacific salmon and western trout in British Columbia. N. Y., Wm. Morrow and Co., 356 p.

Miller, Robert Rush
1950. Notes on the cutthroat and rainbow trouts, with the description of a new species from the Gila River, New Mexico. Univ. Mich., Mus. Zool., Occ. Pap., no. 529, 42 p.

Murphy, Garth I., and John W. DeWitt, Jr.
1951. Notes on the fishes and fishery of the lower Eel River, Humboldt County, California. Calif. Div. Fish and Game, Bur. Fish Cons., Admin. Rept., 30 p. (Mimeo.)

Neave, Ferris
1949. Game fish populations of the Cowichan River. Fish. Res. Bd. Canada, Bull., no. 84, 32 p.

Snyder, John Otterbein
1908. The fishes of the coastal streams of Oregon and northern California. U. S. Bur. Fish., Bull., vol. 27, p. 153-189.
1940. The trouts of California. Calif. Fish and Game, vol. 26, no. 2, p. 96-138.

Sumner, F. H.
1948. The coast cutthroat trout. Oregon St. Game Comm., Bull., vol. 3, no. 12, p. 1-8.

SALMO ROSEI, NOT A VALID SPECIES[1]

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California Department of Fish and Game

Jordan and McGregor (1924) described "a new species of trout," *Salmo rosei*, from Lake Culver and one adjacent lake in the high Sierra of California. They stated that it was an "ally or derivation of the Kern River trout (*Salmo gilberti*) Jordan."

Subsequently, Jordan, Evermann, and Clark (1930, p. 59), Evermann and Clark (1931, p. 47, 50), and Snyder (1933, p. 84), all listed *Salmo rosei* as being present in Lake Culver "and neighboring lakes." In discussing its systematic status, Snyder (1933, p. 106; 1940, p. 128) stated: "Its relationships are said to be with the golden trout of the region. There is difference of opinion as to whether this is a native fish or one introduced through artificial stocking." Nevertheless, in both publications Snyder listed it as a distinct species of the rainbow series. In the absence of published information disproving the validity of the form, Shapovalov and Dill (1950) listed it as a subspecies of *Salmo gairdneri*. Recently gathered evidence, presented in this paper, shows definitely that "*Salmo rosei*" is not a valid entity.

Lake Culver, named by Jordan and McGregor, can be identified from their description as the largest of the group now known as the Little Five Lakes in Tulare County. It is located in T. 16 S., R. 32 E., Sec. 30, at an elevation of 10,500 feet, and is tributary to Big Arroyo, a tributary of the Kern River. This location has been verified by Mr. Egerton Lakin of Palo Alto, California, who aided in the collection of specimens there in 1923 (verbally to Shapovalov, February 26, 1946).

Since, so far as is known, all the other lakes in this area were originally barren of fish, it has seemed doubtful to the authors that the form could have been native here. Additional verification of this belief came in 1947 when Drs. Carl L. Hubbs and W. I. Follett examined all the type material of *S. gilberti* and *S. rosei* in the Stanford University collections and found no differences between the two forms. Hubbs and Follett did not publish their findings but have now given us permission to do so. Together with the following material, these clinch the case against *S. rosei* as a distinct entity.

On October 28, 1953, the authors talked with Mr. O. P. Brownlow of Visalia, retired Captain of Patrol, California Division of Fish and Game. Mr. Brownlow worked for many years in the southern Sierra Nevada, where he was instrumental in stocking barren waters and in gathering the history of such endeavors. He informed us that Lake Culver was originally barren of fish and was planted in about 1916

[1] Submitted for publication March, 1954.

with adult trout caught on hook and line from the Big Arroyo. He received this information from a Mr. William Millinghausen (sp.?), a cowpuncher and packer in the area, who had planted the fish. Incidentally, Mr. Brownlow was at Lake Culver in late July or early August of 1923 when at least one of the described specimens was taken. He informed us that the fish were trying to spawn near the outlet and to him did not appear to differ from the Kern River rainbow, with which he was quite familiar.

In view of the combined evidence presented, we can only conclude that *Salmo rosei* is a synonym of *Salmo gilberti,* now known as *Salmo gairdneri gilberti* Jordan.

LITERATURE CITED

Evermann, Barton Warren, and Howard Walton Clark
1931. A distributional list of the species of freshwater fishes known to occur in California. Calif. Div. Fish. and Game, Fish Bull. no. 35, 67 p.

Jordan, David Starr, Barton Warren Evermann, and Howard Walton Clark
1930. Check list of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Colombia. U. S. Commissioner of Fisheries, Rept. for Fiscal Year 1928; with appendixes; pt. 2, appendix 10, 670 p.

Jordan, David Starr, and Ernest Alexander McGregor
1924. Description of a new species of trout (Salmo rosei) from Lake Culver in the high Sierras of California. Acad. Nat. Sci. Phila., Proc., vol. 76, 1924, p. 19-22, pl. 2.

Shapovalov, Leo, and William A. Dill
1950. A check list of the fresh-water and anadromous fishes of California. Calif. Fish and Game, vol. 36, no. 4, p. 382-391.

Snyder, John O.
1933. California trout. Calif. Fish and Game, vol. 19, no. 2, p. 81-112.
1940. The trouts of California. Calif. Fish and Game, vol. 26, no. 2, p. 96-138.

NOTES

TWO MID-PACIFIC RECOVERIES OF CALIFORNIA-TAGGED ALBACORE

Two albacore (*Thunnus germo*) tagged by the California Department of Fish and Game off the coast of northern Baja California, Mexico, in August, 1953, were recaptured in the mid-Pacific during February 1954. Both were caught by Japanese vessels fishing in the vicinity of Midway Island.

Fisherman aboard the Konpira-maru No. 1 of Miyagi Prefecture caught the first fish on longline gear at lat. 36° 40′ N., long. 178° 12′ E., 500 miles north of Midway Island, on February 2, 1954. It was tagged with a Type F tag of clear vinylite tubing secured by braided nylon fishing line. When released on August 11, 1953 the albacore was 84 cm. long. It had increased in length to 88 cm. when recaptured. The straightline distance between the points of release and recovery is 3,035 miles.

The second albacore was caught on February 23, 1954, by the Sin-o-maru (Iwate Prefecture) while fishing with longlines at lat. 30° 10′ N., long. 178° 54′ W., 150 miles northwest of Midway Island and 2,990 miles from the place of release. It was marked with a Type G vinylite tubing tag on August 16, 1953. At that time the fish was 91 cm. in length; it was reported to be 93 cm. long when caught by the Sin-o-maru.

Both of these recoveries are from 754 albacore tagged in the vicinity of Guadalupe Island. There have been 12 other returns from this lot. All occurred off the central California coast within 45 days of release.

The tags were received by the Department of Fish and Game through the fine cooperation of Hideyuki Hotta and Masakaza Yao of the Tohoku Regional Fisheries Research Laboratory, Shiogama, Japan, and Hiroshi Nakamura, Director of the Nankai Regional Fisheries Research Laboratory, Kochi, Japan.

These returns do not represent maximum known movements, as an albacore tagged off Southern California in 1952 was recaptured off the coast of Japan during the summer of 1953 (Ganssle and Clemens, Calif. Fish and Game, vol. 39, no. 4, 1953, p. 443). The tags used are described by Wilson (ibid., p. 429-442).—*C. E. Blunt, Jr., Marine Fisheries Branch, California Department of Fish and Game, March, 1954.*

ANOTHER LARGE BLACK SEA BASS CAUGHT IN MONTEREY BAY

On August 29, 1953, a California black sea bass, *Stereolepis gigas* Ayres, was caught off Pacific Grove, in the southern portion of Monterey Bay. The specimen, which measured six feet, two inches and weighed 265 pounds, was caught by Charles May of Pacific Grove and his son. The two were fishing in a skiff, using rod and reel and a 50-pound test leader, when they hooked the large fish. It took them two and one-half hours to boat it. The last record of a black sea bass from Monterey Bay was of one taken April 30, 1930 (Phillips, Calif. Fish and Game, vol. 16, no. 3, 1930, p. 268). This specimen weighed 450 pounds and was also caught by a skiff fisherman in approximately the same area as the recent specimen.—*J. B. Phillips, Marine Fisheries Branch, California Department of Fish and Game, February, 1954.*

ABNORMAL FETAL DEVELOPMENT FROM A MULE DEER

In 1951 a food habits and disease investigation of Rocky Mountain mule deer (*Odocoileus hemionus hemionus*) was conducted in Sierra County, California. During this study a fetal cyclopean monster was taken from a normal four- to five-year-old doe (Figure 1). This type of developmental abnormality has not previously been observed in mule

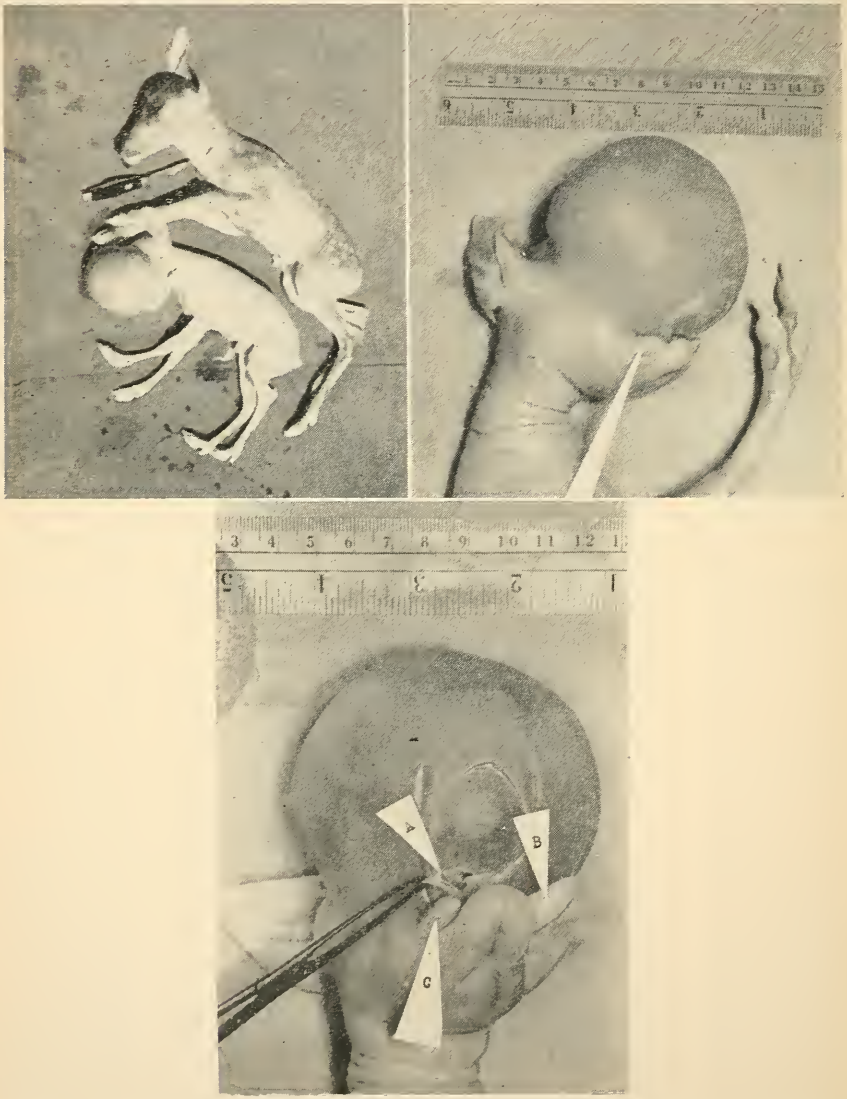

FIGURE 1. *Top left:* two male fetuses, the meningocephalic and its normal twin. *Top right:* side view revealing the hypoplasia of the upper jaw and sac-like development of the skull. *Bottom:* ventral view showing (A) eyes, (B) tongue, and (C) upper jaw. *Photographs by author and John R. Azevedo.*

deer, although it has been described for other mammals. A developmental difference was readily noticed when it was compared with its normal twin. The age of the normal fetus was determined to be approximately 150 days, while the monster's development was equivalent to 120 days, according to Armstrong's (1950) method. This monster was pinkish in color, without hair, and lacked evidence of juvenile spots. Examination of the head revealed a hypoplasia of the upper jaw. The eyes were fused at the median line in a single orbit, and the vault of the cranium was absent, resulting in a bulging sac-like structure filled with fluid. The cerebrum consisted of a thin sheet of brain tissue lining the bony portion of the cranium. The mid- and hindbrain were greatly reduced. No other anatomical abnormalities were observed. Its general appearance led to the belief that the fetus was alive at the time the doe was collected.

REFERENCE

Armstrong, R. A.
1950. Fetal development of the Northern white-tailed deer (*Odocoileus virginianus borealis* Miller). Amer. Midl. Nat., vol. 43, no. 3, p. 650-666.

—*Arthur I. Bischoff, Game Management Branch, California Department of Fish and Game, February, 1954.* *This work was performed as part of Pittman-Robertson Project California W-35-R.*

REVIEWS

Striped Bass Fishing in California and Oregon

By Leon D. Adams; Pacific Books, Palo Alto, California, 1953; xiv + 224 p; foreword by Alex Calhoun; drawings by Patricia Talbot. $5.

In the waters of San Francisco Bay and its tributaries lives a remarkable fish. It is not the only game fish of this area, nor of the Oregon bays where it is also found. But as far as many thousand fishermen are concerned, it is the only fish in the world. Something about the striped bass transforms otherwise sensible people into wild eyed, single purpose fanatics. Men and women who scorn to fish for the lordly salmon or wily trout will leave their homes in the middle of the night for a chance to sit all day in the rain or wind to catch a striper.

What is there about this fish that makes them so irresistible? Is it not for the fisheries scientist to say. The story of the striper can come only from one who has succumbed to its allure. And no one has a worse case of "striper itis" than Leon Adams. Only he can tell us all about the bass and how to fish for them.

Mr. Adams was bitten by the bug many years ago. Sometimes he caught fish, often he failed. But the failures, instead of discouraging him, served to spur him on. There must be a reason for his spotty success he thought, and there must also be a reason for the consistent catches of some old-timers. So he set himself to the task of plotting the stripers' movements, habits and moods. He sought advice both from expert anglers and scientists.

During a 16-year period, under attack by every known device of science and mathematics, including an enormous bulk of information tabulated on punch cards, the bass yielded its secrets. Mr. Adams has done the job and now all that remains is for the reader to follow his advice and catch fish. Some of my friends have done just that, they tell me.

This reviewer has read many a book on how to fish but few of them contain so much useful information presented so engagingly. The book might have been full of facts but too dull to read, or it might have been one of those clever but frothy "me and Joe" stories. But Adams is too skillful an observer and writer to fall into either trap.

The result is a book so interesting it can't be put aside, so factual it can't be ignored. Whether he be beginner or veteran any would-be bass fisherman will profit by reading this book, and he who reads it soon finds himself a striper enthusiast.

The usual information on tackle, bait and lures is included. Both text and illustrations are descriptive. Most valuable is the material on how to find the migratory bass when you want to catch them. The combination of fishermen, scientists and mass data reveals secrets only guessed at previously by fishermen. The bass calendar is something new in angling. The life history of the striper is recounted in an easy going manner that ties its habits to those of the fisherman and gives them meaning. Instructions are so complete that they even include a chapter on alibis and their cures. What more could a fisherman ask?—*Richard S. Croker, California Department of Fish and Game.*

Our Wildlife Legacy

By Durward L. Allen; Funk and Wagnalls Company, New York, 1954; x + 422 p., 26 photos. $5.

Although there has been a fair quantity of books on wild life in the United States during recent years, there has been a great scarcity of comprehensive writings which satisfactorily bridge the gap between what the professional wildlife biologist knows (or needs to know) and what the nonprofessional reader of wildlife lore should know. Dr. Allen's attempt to write a general book in everyday language, yet based upon scientifically sound ecological principles, has been one of the most successful attempts in recent years. In his preface, the author states, "This work is neither a professional job of debunking nor an indictment of anyone in particular. It is not

another climb-upon-my-knee interpretation of deep science for the dumb public." But the author does present a straightforward, hard hitting account without the all too common polemics and panaceas.

In the first of three parts of the book, "Numbers at Work," a simple description of the principles of population biology is given. The role of the environment to the maintenance of wildlife populations is emphasized in its proper perspective in relation not only to population numbers and environmental "carrying capacity" but also to birth rates, death rates, and the tendencies of some populations to fluctuate. Particularly valuable are accounts of the resiliency of populations to natural and man-caused depredations and accounts of the birth and death rates which make this resiliency possible—accounts which should be read and reread by everyone concerned with natural populations. The chapter, "Boom and Bust," dealing with cyclic fluctuations, contains examples and discussions of populations which are generally regarded by biologists to be truly cyclic in nature, but detailed discussions of supposed basic cosmic causes of these cycles are wisely omitted. Mention of cycles among Pacific salmon species is conspicuously absent.

In Part II, "Paths and By-paths," the intricate relationships among biologists, wildlife managers, legislative bodies, and the sportsmen are described by using as illustrations management practices which have been tried for various species. In each case erroneous concepts of management are pointed out, and the correct concepts and correctly applied techniques are thoroughly evaluated. For the reader without technical training, this section of the book should go a long way to clarify the problems of fish and game management and to explain why biologically sound solutions are necessary.

In Part III, "The Method and the Outlook," the future of fish and game activities in the United States is astutely appraised. Four chapters, "Lead Kindly Light," "Biopolitics," "We Call It Yours and Mine," and "The Pilgrim's Pride," are timely discussions on the role of research, on the "political arena," on private property rights and the availability of fish and wildlife environment which the public may enjoy, and finally on man's responsibility of preventing the earth from becoming a "biological slum."

There are few errors or omissions which detract from the author's general themes. Although great emphasis is properly placed on the maintenance of terrestrial and freshwater environments and their wildlife resources, little mention is made of the marine environment and its increasingly important resources.

The book is written in easy-to-read style, highly colored with colloquialisms and catchy phrases, which add to reader interest without detracting from the main theses. There are no literature citations, graphs, tables, or diagrams to detain the reader when a thought is being pursued. But there are 57 appended pages of reference notes covering the material presented in all but the last chapter; the reference notes contain brief discussions of data and ideas presented in the various chapters with further reference to a selected bibliography of 501 entries. Perhaps *the* outstanding feature of the book is the illustration of principles of population biology by the use of examples pertaining to fish, fowl, and furbearers, thus emphasizing the generality of these principles rather than having them adumbrated in separate sections on each kind of wildlife. This feature alone makes the book a worthy addition to the libraries of all who are interested in wildlife.—*Donald E. Wohlschlag, Natural History Museum, Stanford University, California.*

The Practical Fly Fisherman

By A. J. McClane; Prentice-Hall, Inc., New York, 1953; ix + 257 p., illustrated by Walter Dower. $5.95.

A. J. McClane is an analytical angler who writes a literate column for *"Field & Stream."* Some of his magazine articles have now been used, in well integrated form, as the basis for "The Practical Fly Fisherman."

Following a somewhat florid introduction, the book begins with a discussion of the fly rod and its mechanics. The next chapter is on casting, followed by one on lines and one on leaders. There are chapters on nymph fishing, the dry fly and the wet fly, and bucktails and streamers. There is even one devoted exclusively to spiders. ("Of all trout flies, the one you can least afford to be without is the spider.") There is a chapter on fly fishing for bass and one on panfish. A special chapter, "How to Cast Beyond Sixty Feet," describes the double line haul, tip fishing, and the so-called Belgian style of casting.

Some of the discussions and terminology may be a little advanced, and, therefore, may not hold the beginner's uninterrupted interest. But the writing is clear, and McClane's theories are based on sound reasoning. His suggestions for the selection of flies are as sensible as any I have ever read. And, incidentally, he offers an excellent explanation as to why the one-pattern anglers, the believers in exact imitation, and the impressionists may all be equally successful in taking fish.

There are five plates of flies painted in color by Walt Dower. Unfortunately, the keys to these plates, i.e., names and descriptions of the flies, are too far removed from the plates themselves. Of most interest among them is a reproduction of eighteen of Dame Juliana Berners' fly patterns, the earliest set of trout flies in history. They are reproduced for the first time in color from the descriptions written in "A Treatyse of Fysshynge wyth an Angle," published in 1496.

This is a good book, and this review can best end with the author's own advice: "And now it is time to get on with the angling. We shall talk much and fish some, and possibly our innocent design will compound a brew that will go off with an explosion, should we trap a reader who was unfamiliar with the ways of an angler. Perhaps he will regret his years spent away from rivers and number his years in their wisdom. If so, let us fill our cup and drink to the coming fly-fisher. May his days be blessed in sweet merriment."—*William A. Dill, California Department of Fish and Game.*

Baja California

By Ralph Hancock with Ray Haller, Mike McMahan and Frank Alvarado; Academy Publishers, Los Angeles, 1953; 180 p.; illustrated, $5.

If, in 1950, a census had been taken listing all of the books ever published on Baja California, the census taker could probably have tallied the entire lot on the fingers of both hands. Of these approximately 10 tomes only E. W. Nelson's "Lower California and Its Natural Resources" seems to have been overlooked by the author of this present volume. Even though lacking this important work, the author's complete knowledge of the others blended carefully with several leisurely vacation treks throughout the entire length and breadth of the Baja California peninsula and liberally sprinkled with some very fine photographs seems to have become the perfect recipe for a combination travelogue, guidebook, almanac, and saga of modern adventure.

This book is mostly concerned with south of the border travels of four Los Angeles businessmen. It takes the reader over an assortment of roads—mostly narrow and rough—through an assortment of amazing and unbelievable country—mostly desert—lying between latitudes 32.5° and 23° N.—a distance of some 650 miles as the crow flies. Because they are never too busy nor too impressed with a sense of their own importance to detour miles or even days out of their way to run an errand, deliver a package or otherwise render some slight service to a person entirely unknown to them, the four travelers—and therefore the readers—are privileged to share in a portion of the everyday, simple existence of the rural bajacalifornianos; an existence of which the average vacationer is seldom cognizant.

The first time the reader's eye encounters a lengthy list of fish or game said to be commonly taken at a particular locality there is a natural tendency to snort in derision (having assumed—and logically it seems—that the list was most certainly copied verbatim from a tourist folder or similar testimonial). That precisely was the feeling of this reviewer, until a second glance brought a realization of personal acquaintanceship with the fishing at many of the localities in question. Actually, most of these lists do the fish fauna a grave injustice by their brevity and if secondhand reports are to be accepted the same statement holds with regards to game.

For those individuals planning extended vacations in Baja California, there is a complete detailing of protocol attendant with obtaining visas, plane or hotel reservations, below the border insurance, vaccinations, and dozens of related trivia, much of which is likely to be overlooked by the inexperienced—thus causing unnecessary delays. In this department alone, by saving time and the expense of medicating last-minute headaches, "Baja California" more than repays its purchase price.—*John E. Fitch, California Department of Fish and Game.*

Handbook of Freshwater Fishery Biology With the First Supplement

By Kenneth D. Carlander; Wm. C. Brown Company, Dubuque, Iowa, 1953; v + 429 p., 2 figs. $6.50.

Undoubtedly every fishery scientist in the United States and Canada is aware of Professor Carlander's indispensable "Handbook." Since its publication in 1950, its summarized life history data and extensive bibliography have proven to be a convenient and valuable aid in both freshwater fishery research and management. Now the author has gleaned from more recent literature a wealth of additional data and included it in a "First Supplement." This new summary is offered in a new edition of the "Handbook," or may be obtained separately for $3. The combined edition saves the purchaser of both works $1.

The new edition of the "Handbook" is essentially the same as the original one. Some errors in the first edition have been corrected and a few minor errors have been preserved. Most of these errors, it seems, concern specific names of fishes and result from recent rulings in nomenclature. These few oversights can be easily corrected in future editions.

The "Supplement" contains age and growth and other life history data for 146 species of freshwater fishes of the United States and Canada. Most of this information is derived from more recent studies of species covered in the "Handbook," but 36 additional species (mostly non-game) are also covered. Of these, 12 are cyprinids and four are catostomids. The "Supplement" summarizes not only the literature, but the "Handbook" as well. Whenever sufficient data on a given species were available in the "Handbook," the median of the means from various bodies of water is recorded for comparative purposes. In some cases, the first and third quartiles are given also.

While most of the "Supplement" is devoted to age and growth, length-weight relationships, and conversion factors between standard, fork, and total length measurements, there is also interesting information about fecundity, annual yield, creel censusing, population density, and other phases of freshwater fishery biology. The bibliography contains 447 titles.

The only weakness in the author's painstaking presentation appears to be his arbitrary exclusion of the striped bass and all species of *Oncorhynchus*. Not only do these fishes spend the most critical stage of their life histories in fresh water, but they also provide considerable sport for freshwater anglers. Future editions should include them.

In anticipation of future supplements to the "Handbook," let all professional fishery biologists hope that the author is not deterred in his labors. His compilation of this vast amount of widely scattered data is an outstanding contribution to the young science of freshwater fishery biology.—*George W. McCammon, California Department of Fish and Game.*

The Black River Studies

By John L. Funk, Edward M. Lowry, Mercer H. Patriarche, Robert G. Martin, Robert S. Campbell, and Timothy R. O'Connell, Jr.; The University of Missouri Studies, vol. 26(2), Columbia, Missouri, 1953; 136 p., 11 figs. $2.50.

The Black River is an Ozark smallmouth bass stream. In 1947 a cooperative research project was initiated by the Missouri Conservation Commission and the University of Missouri in order to obtain detailed data concerning the effect of a nearly complete impoundment upon the stream fishes and bottom fauna of the Black River. Impoundment was completed in 1948. The project was continued until 1950. Thus, both pre- and post-impoundment data were obtained.

The results of the investigations are presented in a unique, but somewhat repetitious, fashion. The work is composed of seven separate, but closely related, sections. Each section was prepared by one or more of the authors and each is a complete unit in itself that could be published alone with little or no loss of meaning. The reviewer, however, is not certain that this method of presentation is worth the effort, since each separate section contains a considerable amount of reference to the other sections. A more concise presentation might have been more effective. At least reading time would have been significantly shortened.

The first section or chapter describes the physical and chemical characteristics of the Black River. Three subsequent sections deal with the benthos, small fishes, and larger fishes of the Black River and the changes that occurred in the populations of these organisms when the Clearwater Lake impoundment was completed. The fifth section contains age and growth data about five of the more important fishes, and the sixth section treats past management and utilization of the Black River fishery. The last section summarizes and relates the findings of the previous sections and reiterates the highlights of the studies. The methods and procedures are given in an appendix.

This publication is solid evidence of the recent progress made in freshwater fishery research and management. The Missouri workers now posses a solid foundation for future management of the Black River and similar Ozark streams. Furthermore, they will be able to predict the effects of impoundment upon such a stream. If such data were available for other streams in the United States, much of the guesswork that has characterized past management techniques and policies could be eliminated.

Although the specific, detailed information presented in this technical publication will be of little interest outside of the midwest, all freshwater fishery biologists, especially those involved in warmwater projects, will benefit by reading it. *George W. McCammon, California Department of Fish and Game.*

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